

EPITOME

OF THE

Art of NAVIGATION;

James: *Blindburn*
G. R. A

Short, Easy and Methodical Way to become
a Compleat Navigator;

CONTAINING,

Practical Geometry, Plain and Spheric,
Superficial and Solid; with its USES in all
Kinds of Mensuration.

Trigonometry, Plain and Spheric, both Geometric,
Instrumental, and Logarithmic; with its USES
in NAVIGATION, viz.

In Plain, Mercator's, and Great-Circle-Sailing, Geo-
graphy. Astronomy, the Projection of the Sphere, &c.

The Description and Use of the Plain Chart, Mercator's Chart,
both Globes, Hemispheres, and divers other Instruments.

A New Form of keeping a Sea-Reckoning, or Account of a
Ship's Way.

A Traverse Table; A Table of Meridional Parts; a Table of
10,000 Logarithms, and Logarithmic Sines, Tangents and
Secants, carefully Corrected.

By JAMES ATKINSON, Senior.

The whole revis'd, and corrected, with the utmost care,
By William Mounslaine, Teacher of the Mathematics.

L O N D O N:

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W. James: Blindburn
his Book



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To all Lovers and Learners O F NAVIGATION.

THE General Approbation of this Book, since its first Impression in 1686, hath obliged me not only to publish my *Grateful Acknowledgment* thereof; but also excited my diligent Search into, and exact Survey of every Part of it's *Structure*, to find out the *Defects*, to know all its *Deficiencies*, which I have so far laboured in, That in this Tenth Impression,

I have now *Rectified* what was Amis; *Alter'd* what was Disorderly; *Explain'd* what was Dark or Obscure; *Enlarged* where it was Scanty, *Added* where it was Wanting. And,

These *Rectifications*, *Alterations*, *Emendations*, and *Additions*, being in divers Places, I thought it needless to *Enumerate* them; for they are obvious to a diligent Reader, that will but compare the *Rules*, *Precepts*, and *Examples* of this with the former *Impressions*, in the plain and easy Method they are placed in, which is thus;

I. You have *Practical Geometry*, explained by Definitions, Problems and Proportions, In this Chapter is taught the making the most useful Geometric Figures, with the measuring all Superficies and Solids; Also the Application thereof in *Practical Measuring*, Board, Glass, Plastering, Painting, Paving, and Land; Timber, and Stone; Gauging of Casks, and a Ship's Hold: All being illustrated with Rules, Proportions, and Examples, easy to the Understanding, and not burthensome to the Memory; and so stated that they may be performed both by Arithmetic, and by the Line of Numbers on Gunter's Scale, in 37 Problems. The

The first Chapter I advise the Learner to study well before he proceed, it being preparative to the next, as indeed they are all depending on one another, as Links in a Chain.

II. Plain Trigonometry is next, in which are many useful Notes and Definitions, with the Axioms, and also the Cases depending on each Axiom, orderly set down in 8 Problems, containing 13 Cases.

And here I must advertise the Young Student that would work Trigonometry by the Logarithms, to consult Chapter 1. The Explanation and General Use of the Table of Logarithms, and Tables of Sines, Tangents, and Secants, towards the latter End of the Book; in Page 294.

III. Then follows Plain Trigonometry, applied in Problems of Sailing by the Plain Sea-Chart commonly called Plain Sailing.

And that nothing be wanting, I begin with the common Notes of the Julian Kalendar; shewing how to find the Prime, Epact, Dominical Letter, Easter Day, the Moon's Age, Southing, and Time of Full-Sea, or High-water, In 9 Problems.

Then proceeding to the Description and Use of the Plain Chart, in 5 Problems, before I come to the Cases of Plain Sailing, which I divide into 3 Parts.

1. *In a Right angled Triangle, relating to a single Course, in which are 6 Cases, commonly called the 6 Cases of Plain-Sailing.*

2. *In a Right-angle Triangle, relating to several Courses called a Traverse.*

3. *In an Oblique Triangle, in which are but 4 Cases, though there may be a Multitude of various Questions; of which you have a Taste in Turning to Windward, and Sailing in Currents, In 21 Problems.*

IV. *In Chapter 4th is Mercator's Sailing: To the right understanding of which, 'tis necessary to describe Mr. Wright's Projection, commonly known by the Name of Mercator's Chart, and shew the Uses of it; before I treat of the Problems of Sailing by it; which you will find performed in 12 Problems. In the last of the Table of Meridional*
Parts,



Parts, or the Meridional Line on Gunter's Scale is used ; And in Case that Table or Line be wanting, to supply their room, I have added Problems of Sailing by the Middle Latitude, which will nearly agree with Mercator's Sailing, a Thing of good Use, In 4 Problems.

V. Spheric Trigonometry, or the Doctrine of Spheric Triangles Rectangular and Oblique, is next in Order ; and it being so necessary, you shall understand how to make a Spheric Triangle, and also how to measure any of its Parts, before the framing and working Proportions therein, I have fully explain'd that Matter in the beginning of this Chapter, being in a Manner a New Invention, which I call Spheric Geometry ; This you have in 21 Problems.

And in Spheric Trigonometry it self, (the next in Order) you have all the Axioms and Cases, both in Rectangular and Obliquangular Triangles, explain'd with necessary Notes on each Case : As to know when a required Angle is Acute or Obtuse ; and when a required Side is more or less than a Quadrant, In 12 Problems, containing 28 Cases.

VI. The Description and Use of both Globes, is the next to be consider'd ; in which I have plainly and familiarly explained and shew'd the Use of the most necessary Things belonging or relating to each of them, in 24 useful Problems.

To which is annexed a short Description and Use of the Hemispheres, projected on the Plain of the Ecliptic.

VII. Geography is the Subject of this Chapter, which is the Application of Spheric Trigonometry in finding the True Distance of Places in the Variety of their Situation on the Globe of the Earth, In 4 Problems.

VIII. Great Circle Sailing comes next, which as it's the exactest Way of Sailing, so it's the most difficult, and barely possible for a Ship exactly to sail by ; yet it's of great Advantage to keep conveniently near it : for which Purpose you'll find all that necessarily belongs or relates to it, both as to the Projective Part, and that both Stereographic and Gnomonic ; as also in the Calculative Part, which is the Application of both Spheric and Plain Trigonometry,

fully made out: With an Intimation of shortning the Work, by shewing how to describe the Arch of a Great Circle in a Mercator's Chart, In 4 Problems.

IX. Next you have Spheric Trigonometry, applied in sundry Astronomic Problems useful in Navigation, wherein the Circles of the Sphere are described, and the necessary Terms of Art explained to the meanest Capacity, with Respect to the diurnal Motion; and that either,

1. According to the Ptolomaic System, wherein you have in a Right-angle Spheric Triangle, all the Variety of Questions and Examples that relate to the Sun, with Respect to his Longitude, Declination, Right or Oblique Ascension, or Descension, Rising, Setting, Amplitude, Altitude and Azimuth, at the Hour of Six; Altitude, and Hour of the Day, when East or West; Hour, Azimuth, and Altitude, when he is in the Equinoctial, In 24 Problems. Also,

In an Oblique Spheric Triangle, you have great Variety both with Respect to the Sun or a Star, in many Questions and Examples relating to the Sun's Altitude, Azimuth, and Hour of the Day, in any Place, at any time of the Year: And relating to a Star, as to its Longitude, Latitude, Declination, Right Ascension, Rising, Setting, Amplitude, Altitude, Azimuth, Hour of the Night, its Altitude on the Meridian, and Time of its coming to it, In 12 Problems. Or,

2. According to the Pythagorean, or Copernic System, which is now generally receiv'd, as most agreeable to the observed experienced Motion of the Heavenly Bodies; wherein Spheric Trigonometry is applied in variety of Questions and Examples relating to the Earth's Diurnal Motion about its own Axis, once in 24 Hours, whereby all the visible Appearances of the Sun and Fixed Stars are solved, with the Description of the Circles of the Sphere, and how they are drawn Stereographically on the Plane of the Earth's Ecliptic, In 9 Problems.

X. Then follow very easy Rules to find the Variation of the Compass, and how to rectify the Compass, and to Correct the Course thereby, both Arithmetically and Instrumentally, with great Readings. *Also*

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Also here you have the way of Projecting the Sphere Orthographical, In two Problems, with many Examples.

XI. *An Observation, either of Sun or Star; what it is, how or with what, and when 'tis taken; with Rules to find the Latitude of the Place of Observation, and all the Varieties therein reduced unto one Proposition, containing two General Cases, fully explained by many Examples.*

XII. *You have next the Use of all the foregoing Instructions, summarily comprehended in a new Form of keeping a Sea-Reckoning or Journal, wherein the Log-Book and Journal in Words at Length, and Tabular in Figures, are kept together in one Book; whereby the whole proceed, and every particular Transaction of any Voyage at all times may be seen and known, which will be no small Satisfaction to those concerned in Ships and Goods, nor a little Augmentation to the Mariner's Credit and Reputation.*

And that so useful and beneficial a Method might be practised by all who desire to keep a Compleat and Exact Reckoning, and so be enabled to render a good Account thereof, I have largely discribed the Form and Manner of it, with plain Rules and Directions how to correct the Reckoning by the observed Latitude, and how to find what Latitude and Longitude the Ship is in every Day; with an Example of a Seven Days Journal; And how each Days Sailing is managed, in taking it from the Log-Board, casting it up, and bringing it into one Course and Distance; with framing the Dead-Reckoning, and setting it in the Journal: So that by this the Whole is made more intelligible.

Lastly, In the Tabular Part, you have first, a Traverse Table; which tho' it stands in so little Room as two Pages, yet by it the Difference of Latitude and Departure from the Meridian may be found for any Distance under 10,000, and for every Quarter Point of the Compass.

Next to that, A Table of Meridional Parts to every 5 Minutes of Latitude, which together with the Table of Proportional Parts annexed, the Meridional Parts for each single Minute are found. And

And next adjoining is a Table of 10,000 Logarithms.

After which you have a Triangular Cannon Logarithmic, or a Table of Artificial Sines, Tangents, and Secants, to every Degree and Minute of the Quadrant, which are corrected with more than ordinary Care, there being no Volume (when this Book was first published in 1686,) extent that had Secants besides this. The Description and general Uses of these Tables are comprehended in 4 Chapters, containing 13 Propositions, and set just before the Tables, At Page 294.

The Schemes or Figures, are contained in 10 Copper-Plates, inserted in their proper places, being orderly Numbered with proper References for the more easy turning unto upon Occasion.

Thus have you the Sum of what's here treated; what my Labour and Pains have been herein, I leave you to judge who are most like to reap the Fruit and Profit (my Share being a very small Part thereof; tho' I dare aver, it's the Compleatest and Portablest Pile of Instructions (for a Young Learner of Navigation) now extent: It's the very Method I have used for now 50 Years, finding it ever succesful even to the most indifferent Capacity among the many Hundreds I have Taught. Therefore if my Reader would be a Proficient herein, let him begin chearfully, proceed gradually, and the End will crown his Endeavours with answerable Success.

Let not Sloth persuade to give out at the meeting of any Difficulty, but rather remember that Love, Labour and Constancy will overcome the greatest Difficulty. And,

That my Learner may so read as to understand, and so understand as to be a Proficient, is the Desire of him, who wisheth the Young Student's Welfare, and the Progress of Arts.

JAMES ATKINSON.

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EPITOME of the Art of NAVIGATION.

CHAPTER I.

Practical Geometry explain'd by Definitions, Problems and Proportions.

Geometry is a Mathematical Science, explaining the Kinds and Properties of continued Quantity, or Magnitude: that is, a Line, a Superficies, and a Solid, whose Original is from a Punct.

Section I. Of Lineal Geometry, or the first kind of Magnitude.

Definitions. 1. **A Punct** or *Point* is that which cannot be divided into Parts, and is the End of a Mathematic Line, As the Punct A. *Plate 1. Fig. 1.*

2. A *Mathematic Line* hath no Breadth, or Thickness, only Length; it is made by the Motion of a Punct, and (considered in it self) is either Regular or Irregular.

3. *Regular*, is either a Right Line or an Arch.

4. A *Right Line* is the shortest Distance between two Puncts, as the Line BC. *Plate 1. Fig. 1.*

5. An *Arch* is not the shortest Distance between two Puncts, but bendeth evenly, as the Arch DE.

6. *Irregular*, is any crooked Line that bendeth unevenly, as FG. *Plate 1. Fig. 1.*

7. *Lines* compared, are either parallel, or inclining; from whence proceed many Problems.

Problem 1. To draw a Line parallel to a given Line.

Definition. **P**arallel Lines are of equal Distance, and if infinitely produced (being in the same Superficies) will never meet, as the Lines AB and CD. *Plate 1. Fig. 2.*

Example. AB the Line } given.
C is a Punct }

Through which Punct C, and parallel to the Line AB, a Line is required to be drawn?

2. Take

1. Take (with a pair of Compasses) the nearest Distance between the given Point C, and the Line AB.

2. With that Distance (in the Compasses) and one Foot of the Compasses (any where in the Line AB,) draw (that way the Point C lieth) an Arch D.

3. From the Point C, draw a Line to touch the Arch D, and it's done, for the Line CD, is parallel to the Line AB, as was required.

Problem II. *To bisect or divide a given Line into two equal Parts.*

Example. AB is a given Line. Plate 1. Fig. 3.

To find the middle thereof is required?

1. **W**ith any Distance, (greater than half the given Line AB) and one Foot of the Compasses on A, describe the Arch CD

2. With the same Distance, and one Foot on B, cross the former Arch in C and D.

3. By C and D draw a Line which will cut AB in E, the middle; and if AE is equal to EB, it's done true; which point E is the middle of the Line AB, as was required.

Prob. III. *To erect a Perpendicular from a Point in a given Line.*

Definitions. 1. **I**nclining Lines are not of equal Distance, and if produced, will meet, as the Lines AB, and CD. Plate 1. Fig. 4.

2. The meeting of Inclining Lines, (called an Angle) is either Direct or Oblique.

3. *Direct-meeting* of Lines, is when the Angles on each Side are equal, as EGF, and GH; and this kind of meeting is called Perpendicular. Plate 1. Fig. 4.

Example. AB is a Line given.

The Point A one end of it, from whence to erect a Perpendicular is required. Plate 1. Fig. 5.

1. With any Distance, and one Foot in A, draw an Arch to cut the Line AB in D.

2. With the same Distance, and one Foot in D, draw an Arch to cut the former Arch in C.

3. With the same Distance, and one Foot in C, describe an Arch DE, to cut the Line AB in D.

4. By C and D, draw a Line, to cut the Arch DE in E.

5. Then by A and E draw a Line, and it's done: For the Line AE is perpendicular to AB, as was required.

Prob. IV.



Sect. I.

Practical Geometry.

Problem IV. To let fall a Perpendicular, from a given Point to a given Line.

Example. AB is a Line given; C is a given Point: From whence to let fall the Perpendicular to a Line AB is required?

Plate 1. Figure 6.

1. Draw a Line (at pleasure) from C to AB , as is the Line CD .
2. By Problem 2. bisect the Line CD in E .
3. With the Distance EC , equal to ED , and one Foot in E , cross the Line AB in A .

4. By A and C draw a Line, and it's done: For AC is a Perpendicular let fall from the Point C to the Line AB , as was required.

Prob. V. To make a Plain Angle.

Definitions. 1. The meeting of inclining Lines is called an Angle, and the Lines so meeting are called Sides of the Angle, as AB and AC . Plate 1. Fig 7.

2. An Angle is either a Right Angle, or an Oblique Angle.

3. A Right Angle is where two Lines are perpendicular to each other, as ED and DF , Plate 1. Figure 7.

Note, A Right Angle, is just 90 Degrees.

4. An Oblique Angle, is either Acute less than 90 degrees as BAC , or Obtuse more than 90 degrees, GHI . Figure 7.

Note; An Angle is written with 3 Letters, the middle Letter signifieth the angular Point, as BAC signifieth the Angle A .

An Angle is measured by an Arch, whose Center is the angular Point, and is drawn from one Side to the other of the Angle, as the measure of the Angle KLM is the Arch NO ,

Plate 1. Figure 7.

What a Degree is you may see in Problem 9. Definition 1.

Example 1. At A in the Line AB , to make a Right Angle, Plate 1. Figure 7.

The Rule. Upon A (by Problem 3.) erect the Perpendicular AC , and it's done: for the Angle BAC is a Right Angle.

Example 2. At A in the Line AB , to make an Acute Angle equal to 41 degrees. Plate 1. Figure 8.

1. Take (always) a Chord of 60 degrees from your Scale, and with one Foot on A Draw an Arch DE , to cut the Line AB in D .

2. Make the Arch DE equal to the Chord of 41 deg. that is, take 41 deg. from the same Scale of Chords, and lay it on the Arch from D to E .

3. By A and E draw the Line AEC , and it's done; for the Angle BAC is an Acute Angle containing 41 degrees.

Example 3. At B in the Line BC , to make an Obtuse Angle equal to 102 degrees. Plate 1. Figure 8.

I. As

1. As before (with one Foot on B) draw the Arch EF with a Chord of 60 deg. to cut BC in E.

2. On that Arch make EG equal to GF, and each equal to 51d. the half of 102d. that is, take 51d. from the same Scale of Chords, and lay it on the Arch from E to G, and from G to F.

3. By B and F draw the Line BFD, and it's done; for the Angle CBD is an Obtuse Angle, containing 102 Degrees.

Sect. II. Of Superficial Geometry, or the second Kind of Magnitude.

Definitions. 1. A Superficies hath no Thickness, only Length and Breadth, it's made by the moving of a Line; and is either plain, convex, or concave.

2. A plain Superficies, is a Figure flat, smooth, even, and made by the Motion of a Right-line; it's either simple or various.

3. A $\left\{ \begin{array}{l} \text{simple} \\ \text{various} \end{array} \right\}$ Figure or Superficies is bounded by $\left\{ \begin{array}{l} \text{one Line} \\ \text{Lines} \end{array} \right\}$

4. A Figure bounded by one Line, is either a Circle, or an Ellipsis.

5. A Figure bounded by Lines, is either a Triangle, a Quadrangle, or a Multangle.

6. In every Superficies there are three things to be noted.

1. The *Term*, which is that Line or Lines bounding it, as BCDEB. *Plate 1. Fig. 9.*

2. The *Center*, which is a Punct in the middle of it; as A.

3. The *Area*, which is all the Space contained within the Term, as ABCDEBA. *Plate 1. Fig. 8.*

7. The kinds of Plain Figures are seven, a *Circle*, a *Triangle*, a *Quadrangle*, and a *Multangle*, the most easy to make: the more difficult are the *Ellipsis*, *Parabola*, and *Hyperbola*: each affords divers *Problems*, of which we begin with the Circle.

Problem IV. To describe a Circle, having its Diameter given.

Definitions. 1. A *Circle* is a plain Figure bounded by one Line, called the *Periphery*: as ABCDEBA. *Plate 1. Fig. 9.*

2. The *Periphery* of a Circle, is a Line compassing it; so that it's equally distant from the Center, as BCDEB.

3. The *Center* of a Circle is a Punct in the middle of it, from whence all Right Lines drawn to the Periphery are equal, and call'd *Radii*, as A.

4. The *Diameter* of a Circle, is any Right-line drawn thro' the Center to the Periphery; it bisecteth the Circle, and is the longest Right-line that can be drawn in it, as BAD is a Diameter.

Example. BD equal to 60 Inches is given; to make a Circle on or about it, is required? *Plate 1. Fig. 10.*

1. Bisect (by *Problem 2.*) the Line BD in A.

2. With

2. With the Distance AB equal to AD, and one Foot on A, describe the Periphery BCDEB, and it's done.

Problem VII. *To draw the Periphery of a Circle through any three Points, not in a Right Line.*

Example. B, C, and D, are three Points given, thro' them to draw the Periphery of a Circle is required. *Plate 1. Fig. 11.*

1. With any Distance (greater than half CB, or CD) and one Foot in C, draw an Arch FGHI.

2. With the same Distance, and one Foot in B, cross that Arch in F and G.

3. Likewise (with the same Distance and) one Foot in D, cut the former Arch in H and I.

4. By F and G, and H and I, draw Lines to cut each other in A the Center.

5. With the Distance AB, equal to AC, equal to AD, and one Foot on A, draw the Periphery BCDEB, and it's done.

Problem VIII. *To quarter a Circle, or in a Circle to draw two Diameters at Right-angles.*

Example. BCDEB the Periphery, and A the Center of the given Circle; in which to draw two Diameters at Right Angles is required. *Plate 1. Figure 12.*

1. Through the Center A, draw the Diameter BAD.

2. Biseft (by *Problem 2.*) BAD, by drawing the Line CAE, and it's done; and if BC, CD, DE, and EB are equal to each other, it's done true, otherwise not.

Problem IX. *To find the Chord, Sine, Tangent, and Secant of an Arch of a Circle.*

Definitions. 1. If the Periphery of a Circle be divided into 360 equal Parts, they are Degrees; a Degree divided into 60 equal Parts, are Minutes; a Minute into 60 equal Parts, are Seconds, &c. *Plate 1. Figure 13.*

2. The Arch of a Circle is any part of the Periphery; as EB, or EBF; and is counted in Degrees, which are greater or less in Proportion to the Radius of the Circle.

3. *Radius* of a Circle is half its Diameter, or any Right-line drawn from the Center to the Periphery, as AB.

4. A *Chord-line* is drawn from one End of an Arch to the other; as EDF, or EB, are Chord-lines.

5. A *Sine-Line* is half a Chord-line of double the Arch: as ED (being half the Chord EDF) is a Sine-line of the Arch BE, and DF is a Sine-line of the Arch BF.

6. *Versed Sine-Line* is between the Sine-line and the Periphery, as DB is a Versed Sine of the Arch BE equal to BE.

7. *Tan-*

7. *Tangent* toucheth the Periphery, and is perpendicular to a Diameter in the touch Point, as BC is a *Tangent Line* of the Arch BE.

8. *Secant* cutteth the Periphery, being drawn from the Center 'till it meet the *Tangent*, as AC is a *Secant* of the Arch BE.

Example. The Chord, Sine, Tangent, and Secant of 45 deg. are required? *Plate 1. Figure 13.*

1. With any Distance (and one Foot on A) describe the Periphery HIBG.

2. Quarter the Periphery (by Problem 8.) by drawing the two Diameters HAB and IAG; then is BG equal to GH, equal to HI, equal to IB, equal to 90 degrees.

3. Divide (by Problem 2.) BI into two equal Parts in E, and then BE equal to EI, is equal to 45 degrees.

4. Make BF equal to BE, and draw the Lines BE, and EDF, to cut the Diameter HAB in D.

5. At B (by Problem 3.) erect BC perpendicular to the Diameter HAB; or draw (by Problem 1.) BC parallel to the Diameter IAG.

6. By A and E draw a Line to cut BC in C, and it's done.

Then the Line BE is the Chord at 45 deg. the Line EDF the Chord of 90 deg. the Line ED equal to DF, the Sine of 45 deg. DB the versed Sine, BG the Tangent Line, and AC the Secant Line of the same Arch BE, equal to 45 deg.

This Problem is the Ground-work of the Line of Rumbs, Chords, Sines, Tangents, Secants, &c Set on Rulers called Scales; As also of the Degrees on the Quadrant or Cross-Staff, and other Mathematic Instruments.

But its chief Use is in a Right Angled Triangle, as shall be shewed in Trigonometry, when I come to explain the first Axiom in making any side Radius, see Chapter 2. Section 2. in page 36.

Of the Triangles, the 2d Kind of Plain Figures.

Definition 1. A Triangle is any three corner'd Figure, having three Sides and three Angles, as ABC; and in Respect of its Angles, is either Rectangular or Obliquangular. *Plate 1 Fig. 14.*

2. A Right-Angle-Triangle hath one Right-Angle; in its making hath a Perpendicular erected, or let fall, as ABC.

3. Those Sides containing the Right-Angle, are called Legs; as Leg AB, and Leg BC. *Plate 1. Figure 14.*

4. The Side opposite to the Right Angle is called the Hypotenuse; as AC. *Plate 1. Figure 14.*

Prob. X

Prob. X. To make a Right Angle Triangle, the Hypotenuse, and one Angle given.

Note 1. The three Angles of every Plain Triangle (together) are equal to 180 Degrees.

2. To make a Right Angle Triangle, two Things, (besides the Right Angle) and one a Side, must be given.

Example. The $\left\{ \begin{array}{l} \text{Hypotenuse AC 137 Feet} \\ \text{Angle BAC 34d. 30m.} \end{array} \right\}$ given.

With them to make a Right Angle Triangle is required.

Plate 1. Fig. 15.

1. Make the Angle BAC equal to 34d. 30m. (by Prob. 5. Examp. 2.) that is take a Chord of 60d. and with one Foot on A, draw an Arch, and on that Arch lay the Chord of 34d. 30m. drawing AB and AC, which includes the Angle BAC equal to 34d. 30m.

2. Make AC equal to 137 Feet; that is, from any Scale of equal Parts take 137, and lay it from A to C.

3. From C (by Prob. 4) let fall the Perpendicular BC, to cut the Line AB in B, and it's done.

Prob. XI. To make a Right Angle Triangle; the Hypotenuse, and one Leg given.

Example. The $\left\{ \begin{array}{l} \text{Hypotenuse AC 411} \\ \text{Leg AB ——— 342} \end{array} \right\}$ Perches given.

With them to make a Right Angle Triangle is required.

Prob. 1. Fig. 16.

1. Make AB equal to 342 Perches; that is, from any Scale of equal Parts take 342, and lay it from A to B.

2. At B (by Prob. 3.) erect a Perpendicular BC.

3. With 411 Perches: (That is, take 411 from the same Scale of Equal Parts, the 342 was taken) and with one Foot in A, cut the Perpendicular in C.

4. From A to C draw a Line, and it's done.

Prob. XII. To make a Right Angle Triangle, one Leg and one Angle given.

Example. The $\left\{ \begin{array}{l} \text{Leg AB 415 Miles} \\ \text{Angle BAC 40d. 25m.} \end{array} \right\}$ given.

With them to make a Right Angle Triangle is required.

Plate 1. Fig. 17.

1. Make AB equal to 415 Miles, that is, from any Scale of

of equal Parts, take 415, and lay it from A to B. And at B (by Prob. 3.) in Page 12, erect a Perpendicular BC.

2. At A (by Prob. 5. Example 2.) in Page 13. make the Angle BAC equal to 40d. 25m. (which is thus; take a Chord of 60d. and with one Foot on A, draw an Arch, on which Arch lay the Chord of 40d. 25m.) by drawing the Line AC, and it's done.

PROB. XIII. To make a Right Angle Triangle, the Legs given.

Example. The Leg $\left\{ \begin{array}{l} AB \ 404 \\ BC \ 328 \end{array} \right\}$ Leagues given.

With them to make a Right-Angle Triangle, is required. *Plate 1. Fig. 18.*

1. Make AB equal to 404 Leagues. And at B (by Prob. 3.) in Page 12, erect a Perpendicular BC.

2. Upon the Perpendicular make BC equal to 328 Leagues, and from A to C draw a Line and it's done.

Of Oblique-angle Triangles.

Definition 1. An Oblique Triangle hath three Oblique Angles, and is either an Obtuse or an Acute Triangle.

2. An Obtuse Triangle hath one Obtuse Angle, that is, one Angle more than 90d. as BCD. *Plate 1. Fig. 19.*

3. An Acute Triangle hath all its three Angles Acute; that is, each Angle is less than 90d. as EFG. *Plate 1. Fig. 19.*

Note; To make an Oblique Triangle, three things, (and only of them a Side) must be given.

PROB. XIV. To make an Oblique Triangle, two Angles and one side opposite given.

Example. The $\left\{ \begin{array}{l} \text{Angle } \left\{ \begin{array}{l} BCD \ 114d. \\ BDC \ 26d. \ 40m. \end{array} \right\} \\ \text{Side BC } 352 \text{ Miles} \end{array} \right\}$ given.

With them to make an Oblique Triangle is required. *Plate 1. Fig. 19.*

1. Make BC equal to 352 Miles. And at C (by Prob. 5. Example 3.) in Pages 13 and 14. make the Angle BCD equal to 114d. by drawing the Line CD: That is, take a Chord of 60d. and with one Foot on C, draw an Arch, on that Arch lay the Chord of 114d. by taking its half 57d. and laying it twice on the Arch. by which draw the Line CD, thereby you conclude the Angle BCD 114 Degrees.

Ad

2. Add 114d. and 26d. 40m. it's 140d. 40m. the Sum of the given Angles. Which subtract from 180d. 00m. the Sum of the Three Angles.

Remainder is the Angle CBD ——— 39d. 20m.

3. At B (by *Prob. 5. Examp. 2.*) in Page 13. make the Angle CBD equal to 39d. 20m. by drawing the Line DB; That is, with a Chord of 60d. and one Foot on B, draw an Arch, on that Arch lay the Chord of 39d. 20m. by which draw the Line BD, and it's done.

Prob. XV. To make an Oblique Triangle, two Sides and one Angle opposite given.

Examp. The $\left\{ \begin{array}{l} \text{Side } \left\{ \begin{array}{l} BC \quad 274 \\ BD \quad 426 \end{array} \right\} \text{ Miles} \\ \text{Angle } BCD \quad 108d. \quad 30m. \end{array} \right\} \text{ given,}$

With them to make an Oblique Triangle is required. *Plate 1, Fig. 20.*

1. Make BC equal to 274 Miles, and at C (by *Prob. 5, Examp. 3.*) in Pages 13 and 14. make the Angle BCD equal to 108d. 30m. by drawing the Line CD,

2. With 426 Miles and one Foot in B, cut the Line CD in D, and by B and D the Line, and it's done.

Prob. XVI. To make an Oblique Triangle, two Sides, and an included Angle given.

Examp. The $\left\{ \begin{array}{l} \text{Side } \left\{ \begin{array}{l} BC \quad 327 \\ BD \quad 274 \end{array} \right\} \text{ Feet} \\ \text{Angle } CBD \quad 101d. \quad 30m. \end{array} \right\} \text{ given.}$

With them to make an Oblique Triangle is required. *Plate 1, Fig. 21.*

1. Make the Side BC equal to 327 Feet, And at B (by *Prob. 5. Examp. 3.*) in Pages 13 and 14. make the Angle CBD equal to 101d. 30m. by drawing the Line BD.

2. Make BD equal to 274 Feet; and by C and D draw a Line, and it's done.

Prob. XVII. To make an Oblique Triangle, three sides given.

Note, Any two Sides must be greater than the Third, to make a Triangle.

Example. The Side $\left\{ \begin{array}{l} BD \quad 525 \\ BC \quad 425 \\ CD \quad 250 \end{array} \right\} \text{ Leagues given.}$

With them to make an Oblique Triangle is required. *Plate 1, Fig. 22.*

1. Make BD equal to 525 Leagues. Then with 425 Leag. and one Foot in B draw an Arch C.

B 2

2. With

2. With 150 Leagues, and one Foot in D, cut the Arch in C, and from C draw Lines to B, and D, and it's done.

Sect. III. Of Proportions for the ready measuring of Superficies and Solids.

HAVING shewed how to make the most common and useful Geometrical Figures, I now proceed to their (and others) Mensuration, by exact and easy Rules.

Now to prevent the Book's swelling too great, I'll not trouble you with Arithmetic Calculation, but present you with an Instrumental way of Operation, that's quick and true, easy and ready on *Gunter's-Scale*, an Instrument so very well known, it needs the less Description: only to avoid Repetitions take this excellent Rule.

A General Rule for Gunter's-Scale.

Extend the Compasses from the first Term (in a Geometric Proportion) to the second: that Extent (if rightly laid) from the third, will reach to the fourth Term, or thing required.

This Rule well minded, will make what follows appear easy, and save many Words and much Time; and therefore to explain it, take this Proportion.

As 2 is to 6, so is 5 to 15; which I shorten thus;

As 2 .. 6 :: 5 .. 15.

The Extent (on the Line of Numbers) from 2 unto 6, (according to the said General Rule) will reach from 5 unto 15, the fourth Term and thing required.

These Words may be spar'd by the short way of writing the Proportion and minding the Order of the Terms, as in the Problems following. But, for a full Explanation of the *Gunter*, and how to work any Proportion by it, see my Additions to *Mr. WAKELEY'S MARINER'S COMPASS RECTIFIED*. Page 181, &c.

Prob. XVIII. The Diameter of a Circle given; to find its Periphery.

The Rule As $\left\{ \begin{smallmatrix} 7. \\ 1. \end{smallmatrix} \right\}$.. $\left\{ \begin{smallmatrix} 22 \\ 3.14159 \end{smallmatrix} \right\}$:: Diameter .. Periphery.

Example. The Diameter 34 Inches: what is the Periphery?

Ans. Inches 106.8 Tenths of an Inch. For,

As $\left\{ \begin{smallmatrix} 7. \\ 1. \end{smallmatrix} \right\}$.. $\left\{ \begin{smallmatrix} 22 \\ 3.14159 \end{smallmatrix} \right\}$:: 34 Inches .. 106.8 tenths.

That

That is, The Extent of the Compasses, (on the *Line of Numbers*) from 7 to 22, or from 1 to 3.14, &c. will reach from 34 Inches to 106.8 nearest. Observe the like in all the rest.

Prob. XIX. *By the Periphery to find the Diameter.*

The Rule. As $\left\{ \begin{array}{l} 22 \text{ ---} \\ 3.14159 \\ 1. \text{ ---} \end{array} \right\} \dots \left\{ \begin{array}{l} 7. \text{ ---} \\ 1. \text{ ---} \\ 0.3183 \end{array} \right\} :: \text{Periph} \dots \text{Diamet.}$

Examp. The Periphery Inches 106.8 tenths, what is the Diameter. *Ans.* Inches 34. For $22 \dots 7 :: \text{Inches } 106.8 \dots 34 \text{ Inches}$, the Diameter required.

Prob. XX. *The Diameter of a Circle given; to find its Area, or Content.*

The Rule. $\left\{ \begin{array}{l} 1. \text{ Find its Periphery by Prob. 18. Then say,} \\ 2. \text{ As } 1 \dots \frac{1}{2} \text{ Diameter} :: \frac{1}{2} \text{ Periphery} \dots \text{Area.} \end{array} \right.$

Examp. The Diameter 14 Inches; What is its Area? *Ans.* 154 Inches.

By Prob. 18. The Diameter being 14, the Periphery is 44 Inches, and by the Rule it is thus:

As $1 \dots 7 :: 22 \dots 154 \text{ Inches}$, the Area, or Content required.

Prob. XXI. *By the Periphery to find the Area.*

The Rule. $\left\{ \begin{array}{l} 1. \text{ Find the Diameter by Prob. 19. And then,} \\ 2. \text{ The Area is found by Prob. 20.} \end{array} \right.$

Examp. The Periphery 22 Inches: What is the Area? *Ans.* Inches 38.5 Tenths.

The Periphery 22 Inches, the Diameter is 7 Inches, by Prob. 19.

And by Prob. 20, it is thus, As $1 \dots 3.5 :: 11 \dots \text{Inches } 38.5$, the Area required.

Note. The Area of the same Name with the Dimensions taken: That is, if the Diameter, or Periphery be Inches, Feet, or Yards, &c. then the Area is Inches, Feet, or Yards, &c.

Prob. XXII. *To reduce the Area, or Content of any thing found in Inches, to Feet; or into Beer, or Wine-Gallons.*

1. Rule for Feet; say, $144 \dots 1 :: \text{Area in In.} \dots \text{Area in Feet.}$

2. Rule for $\left\{ \begin{array}{l} 282 \\ 231 \end{array} \right\} \dots 1 :: \text{Area in Inch.} \dots \left\{ \begin{array}{l} \text{Beer} \\ \text{Wine} \end{array} \right\} \text{Gallons.}$

This needs no Example; and to avoid the first Rule, take the Dimensions in Foot-measure; that is, 12 Inches, or a Foot

divided Decimally : That is, into 100 equal Parts, called the Line of *Foot-measure*.

Prob. XXIII. *The Diameter, or Periphery of a Circle given, to find the side of the inscrib'd Square, or the Chord of 90 deg.*

The Rule, As 1 .. $\left. \begin{array}{l} .707 \\ .225 \end{array} \right\} :: \left. \begin{array}{l} \text{Diamet.} \\ \text{Periph.} \end{array} \right\} .. \text{Side of the inscribed Square, or Chord of 90d. required.}$

Examp. The Diameter of a Circle being Feet 3.4 Tenths ; What is the Side of the inscribed Square, or the Chord of 90 degrees ? *Ans.* Feet 2.4038 parts of 100.

For ; As 1 .. 0.707 :: 3.4 .. 2.4038 the Chord of 90 deg. or Side of the inscribed Square.

Prob. XXIV. *The Base and Perpendicular of a Triangle given ; to find its Area.*

The Rule. As 1 .. $\frac{1}{2}$ Base :: Perpendicular .. Area required.

Examp. The Base 16 Inches, and the Perpendicular 12 Inches given ; I demand the Area ? *Ans.* 96 Inches.

For ; As 1 .. 8 :: 12 .. 96 the Area required.

Prob. XXV. *The Length and Breadth of a Parallelogram given ; to find its Area.*

Definition 1. A Quadrangle hath four Angles, and four Sides as ABCD ; and is either a Parallelogram or a Trapezia. *Plate 1. Fig. 23.*

2. A Parallelogram hath its opposite sides parallel and equal, as ABCD ; and is either a Square, a Long-square, a Rhombus, or Rhomboide ; the first two are Rectangled Parallelograms, the latter are Obliquangled Parallelograms.

3. A Square hath four equal Sides, and four equal Angles : as ABCD. *Fig. 23.*

4. A Long Square, hath but two Sides equal, and four equal Angles ; as EFGH. *Fig. 24.*

5. A Rhombus, hath four equal Sides, and but two opposite Angles equal ; as IKLM. *Fig. 25.*

6. A Rhomboide, hath only two opposite sides, and two opposite Angles equal ; as NOPQ. *Fig. 26.*

Note, The Breadth of the two last is not IM nor NQ ; But the Perpendicular MN, and QR, and to measure all Parallelograms, observe this General Rule.

As 1 .. Breadth :: Length .. Area required.

E.

Example 1. A Square whose Length AB, and Breadth BC, each is Feet 2.5 tenths: What is the Area? *Answ.* Feet 6.25. parts of 100. For; As 1 .. 2.5 :: 2.5 .. 6.25 Area. *Fig. 23.*

Examp. 2. A Long-square, whose Length EF, is Feet 2.5, and Breadth FG is Feet 1.6: What is the Area? *Answ.* 4 Feet, For; As 1 .. 1.6 :: 2.5 .. 4 Feet the Area. *Plate 1. Fig. 24.*

Examp. 3. A Rhombus whose Length IK is Feet 2.5, and Breadth MN Feet 1.6: What is the Area? *Answ.* Feet 4.

Plate 1. Fig. 25.

For; As 1 .. 1.6 :: 2.5 .. 4 Feet the Area required.

Example 4. A Rhomboide whose Length NO is Feet 25, and Breadth QR Feet 12. What is its Area? *Answ.* 300.

For, As 1 .. 12 :: 25 .. 300 Feet the Area required.

Plate 1. Fig. 26.

Prob. XXVI. *The Diagonal and two Perpendiculars of a Trapezia given; to find its Area.*

Definition 1. A Trapezia, hath its opposite sides and its opposite Angles unequal; as ABCD. *Plate 1. Fig. 27.*

2. The Diagonal, is a Line drawn from its opposite Angles; as AC.

3. The two Perpendiculars, are let fall from the Angles to the Diagonal; as BE, and DF.

The Area of a Trapezia, is found by this Rule.

As 1 .. $\frac{1}{2}$ Diagonal :: Sum of the Perpendiculars .. Area req.

Examp. The Diagonal AC 28 Feet: The Perpendicular BE 15 Feet; and DF 12 Feet: What's its Area? *Answ.* 378 Feet.

For; As 1 .. 14 :: 27 .. 378 Feet the Area required.

Plate 1. Fig. 27.

Prob. XXVII. *The Length and Breadth of an Ellipsis called an Oval given, to find the Area.*

The Rule.

As 1 .. Breadth :: Length .. 4th Number: then say again,

As $\left\{ \begin{smallmatrix} 14 \\ 1 \end{smallmatrix} \right\}$.. $\left\{ \begin{smallmatrix} 11 \\ .78539 \end{smallmatrix} \right\}$:: 4th Number .. Area required.

Examp. The Transverse Diameter of an Ellipsis 12 Feet, and Conjugate Diameter 8 Feet. What's the Area? *Answ.* Feet 75.4.

For, As 1 .. 8 :: 12 .. 96 the Fourth Number.

Then, As 14 .. 11 :: 96 .. Feet 75.4 the Area required.

Prob. XXVIII. *To find the Area of a Parabola.*

The Rule. As 1 .. Axe :: Double Ordinate .. 4th Number: Then, say again As 3 .. 2 :: 4th Number .. Area required.

Examp. The Axe of a Parabola 9 Feet, and the Double Ordinate 8 Feet. What's the Area? *Answ.* 48 Feet.

For ; --As 1 .. 9 :: 8 .. 72 the 4th Number.
And then ; --As 3 .. 2 :: 72 .. 48 Feet the Area required.

Sect. IV. Of Solids, the third Kind of Magnitude.

Definition. A Solid hath Length, Breadth and Depth ; and if bounded by one Superficies, is either a Sphere, or a Spheroid ; but bounded by more than one Superficies is either a Prism, a Pyramid, a Prismoid, or a Pyramidoid ; or compounded of the last, called a Spindle.

Prob. XXIX. The Diameter of a Sphere given, to find the Solid Content.

Definition. A Sphere or Globe, is a Round Solid, whose Length, Breadth and Depth, is alike and equal ; being made by the Rotation, or moving of a Semi-circle about its Diameter ; whose Solid Content is found by this Rule.

As $\left\{ \begin{smallmatrix} 21 \\ 1 \end{smallmatrix} \right\} \dots \left\{ \begin{smallmatrix} 11 \\ .523599 \end{smallmatrix} \right\} :: \text{Cube of Diam.} \dots \text{Cont. required.}$

Examp. A Sphere whose Diameter is Feet 2.42 Parts : What's the Solid Content ? *Ans.* Feet 7.43 Parts of 100.

For ; --As 1 .. 2.42 :: 2.42 .. 5.86 :: 5.86 .. 14.17 the Cube of the Diameter ; Then, Feet

As $\left\{ \begin{smallmatrix} 21 \\ 1 \end{smallmatrix} \right\} \dots \left\{ \begin{smallmatrix} 11 \\ 0.524 \end{smallmatrix} \right\} :: 14.17 \dots 7.43$ the Content required.

In such Cases as this, the readiest Way is to extend the Compasses from the first Term to the third Term ; and that being turned over three times from the second Term, will reach the Thing required.

As here, the Extent from 1 to Feet 2.42, the Diameter, turned three times from 0.524, &c. reacheth to Feet 7.43 Parts of 100, the Content required. For it's thus ;

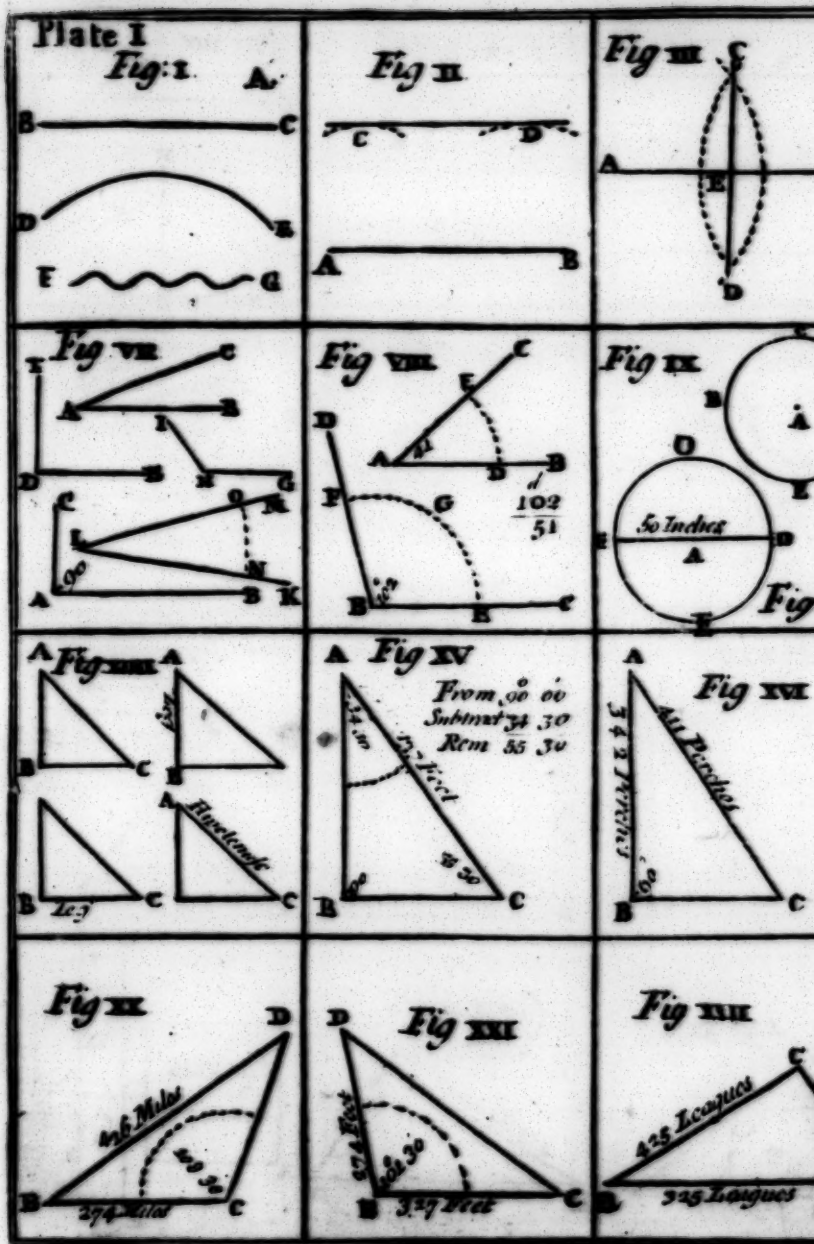
1 .. 2.42 :: 0.524 .. 1.27 :: 1.27 .. 3.07 :: 3.07 .. 7.43, that is,

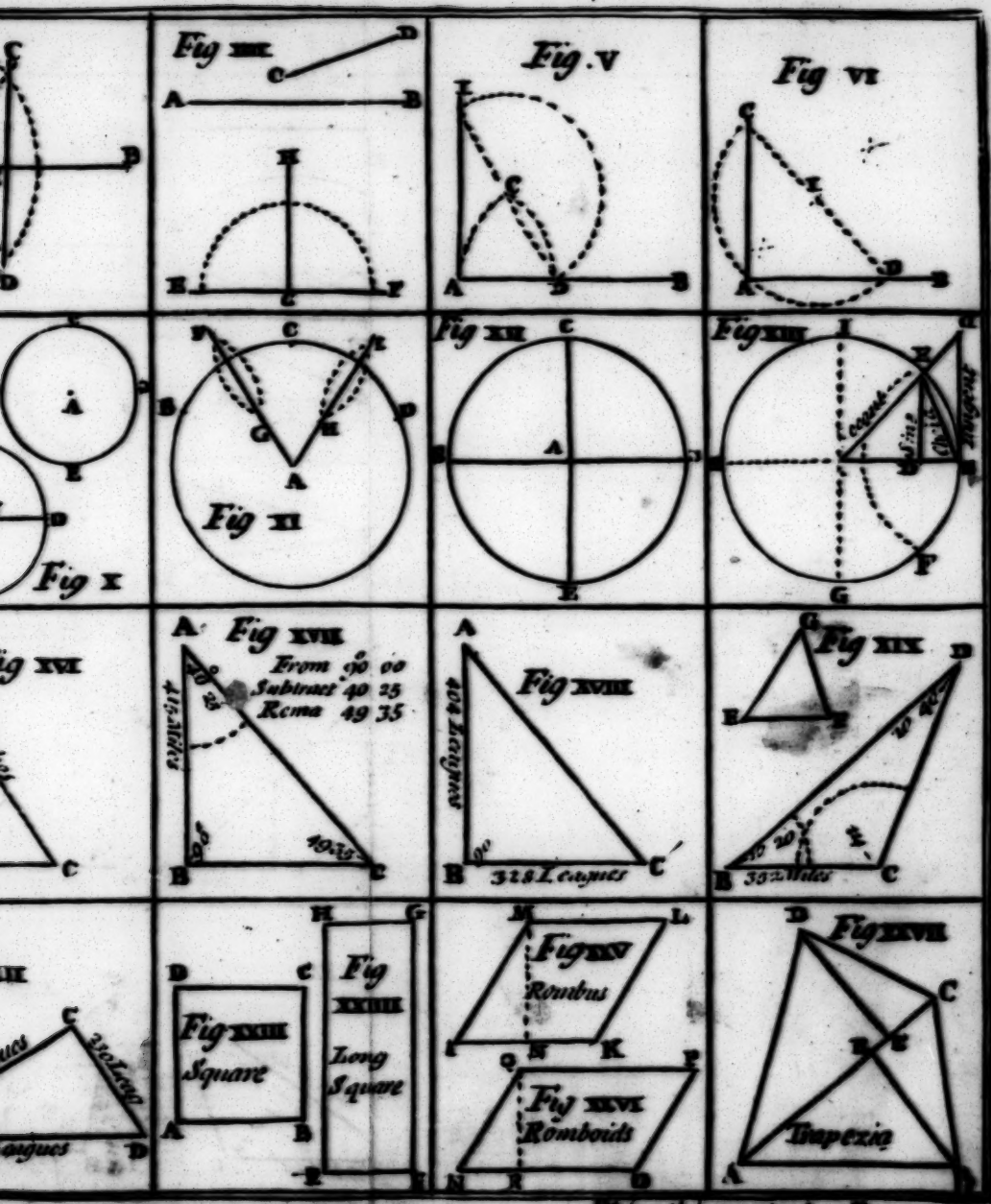
The Extent from 1 to 2.42, (on the Line of Numbers) will reach from 0.524 to 1.27 ; and the same Extent will reach from 1.27 to 3.07 ; and the same Extent from 3.07 reacheth to Feet 7.43 Parts of 100.

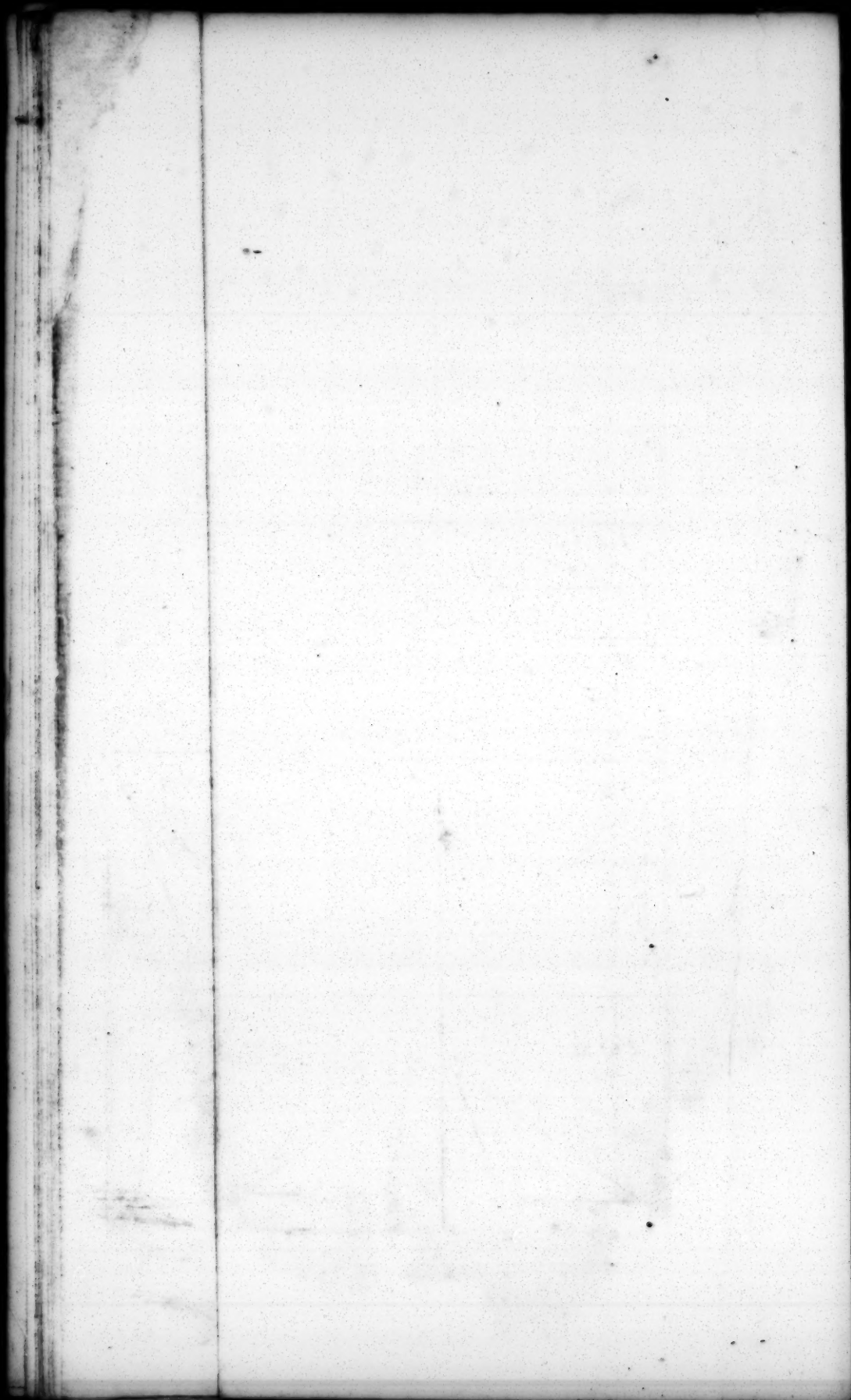
Prob. XXX. The Diameters of a Spheroid given, to find the Solid Content.

Definition. A Spheroid, is an Oval Solid, Longer than it is Broad or Deep ; being made by the Rotation of a Semi-Ellipsis about its Diameter ; the Solid Content is found by this Rule,

As







As 1 .. Square of Depth :: Length .. a 4th Number, then say,

As $\left\{ \begin{smallmatrix} 21 \\ 1 \end{smallmatrix} \right\} \dots \left\{ \begin{smallmatrix} 11. \\ .524 \end{smallmatrix} \right\} :: 4\text{th Number} \dots \text{Content required.}$

Examp. *A Spheroid* whose

Length or Transverse } Diameter is Inches { 7.2 } Tenths.
Depth or Conjugate } { 4.1 }

What's the Solid Content? *Ans.* Inches 63.4 Tenths.

For it's; As 1 .. Square 4.1 :: 7.2 .. 121; here the Extent from 1 to 4.1 is turned twice from 7.2, and it reacheth to 121. Then say,

As $\left\{ \begin{smallmatrix} 21 \\ 1 \end{smallmatrix} \right\} :: 121 :: \left\{ \begin{smallmatrix} 11. \\ .524 \end{smallmatrix} \right\} :: \left\{ \begin{smallmatrix} \text{Inches } 63.4 \text{ Tenths, the} \\ \text{Content required.} \end{smallmatrix} \right\}$

Or thus; As 1 .. 4.1 :: 0.524 .. 2.15 :: 2.15 .. 8.81;

That is, the Extent on the Line of Numbers from 1 to 4.1 will reach from 0.524 to 2.15; and the same Extent from 2.15 to 8.81 Parts of 100.

Then ; As $1 :: 8.81 :: 7.2 :: 63.4$; that is, the Extent from 1 to 8.81, will reach from 7.2 to Inches 63.4 Tenths, the Solid Content required.

Prob. XXXI. *The Dimensions of a Prism given; to find the Solid Content.*

Definition 1. A *Prism*, is a strait Solid, whose two Bases or Ends, are equal, parallel, a-like, and a-like situate.

2. A *Prism*, takes its Sir-Name from its Base; as a Round Prism, a Triangular, a Quadrangular, or a Multangular Prism, all are measured by this one General Rule.

As 1 .. Area of one Base :: Length .. Solid Content.

Examp. 1. A Round Prism, call'd by some a Cylinder, whose Diameter at each End is 21 } Inches.
And Length is 30 }

What's the Solid Content? *Answ.* 10392 Inches.

A Cylinder's two Bases are two equal Circles, and therefore the Area of its Base is found by *Prob. 30.* to be Inches 346.4 Tenths; Then it is,

As 1 :: 346.4 :: 30 :: 10392 Inches, the Solid Content req.

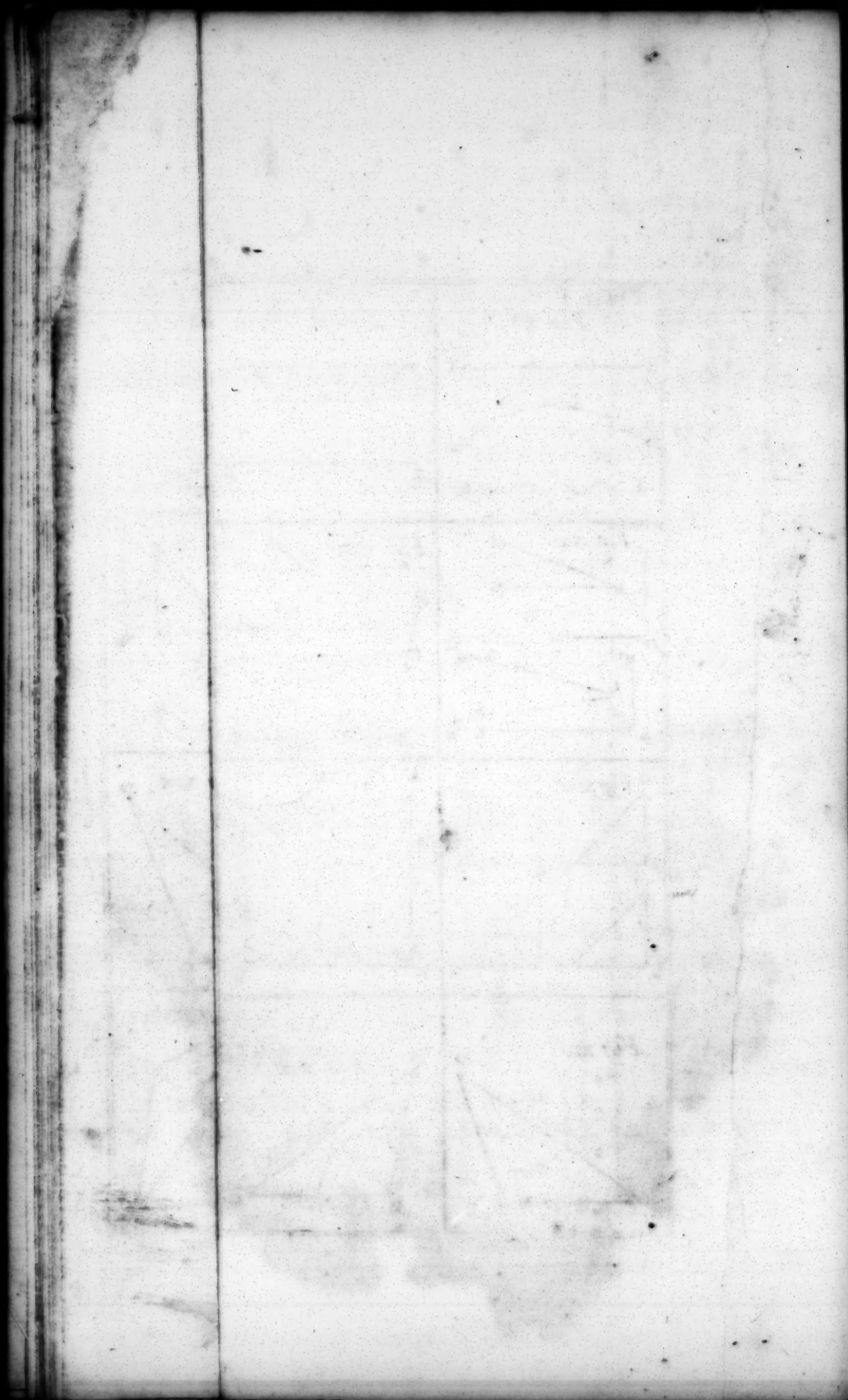
Examp. 2. An Elliptic Prism, whose Bases are equal Ellipses, their

Transverse } Diameter is { 12. } Inches given.
Conjugate } { 8. }

Length of the Solid is 30.

What's the Solid Content? *Ans/w.* Inches 2262.

For



As 1 .. Square of Depth :: Length .. a 4th Number, then say,

As $\left\{ \begin{smallmatrix} 21 \\ 1 \end{smallmatrix} \right\} \dots \left\{ \begin{smallmatrix} 11. \\ .524 \end{smallmatrix} \right\} :: 4\text{th Number} \dots \text{Content required.}$

Examp. A Spheroid whose

Length or Transverse } Diameter is Inches $\left\{ \begin{smallmatrix} 7.2 \\ 4.1 \end{smallmatrix} \right\}$ Tenths.
Depth or Conjugate }

What's the Solid Content? *Answ.* Inches 63.4 Tenths.

For it's; As 1 .. Square 4.1 :: 7.2 .. 121; here the Extent from 1 to 4.1 is turned twice from 7.2, and it reacheth to 121. Then say,

As $\left\{ \begin{smallmatrix} 21 \\ 1 \end{smallmatrix} \right\} \dots 121 :: \left\{ \begin{smallmatrix} 11. \\ .524 \end{smallmatrix} \right\} \dots \left\{ \begin{smallmatrix} \text{Inches } 63.4 \text{ Tenths, the} \\ \text{Content required.} \end{smallmatrix} \right\}$

Or thus; As 1 .. 4.1 :: 0.524 .. 2.15 :: 2.15 .. 8.81;

That is, the Extent on the Line of Numbers from 1 to 4.1 will reach from 0.524 to 2.15; and the same Extent from 2.15 to 8.81 Parts of 100.

Then; As 1 .. 8.81 :: 7.2 .. 63.4; that is, the Extent from 1 to 8.81, will reach from 7.2 to Inches 63.4 Tenths, the Solid Content required.

Prob. XXXI. The Dimensions of a Prism given; to find the Solid Content.

Definition 1. A Prism, is a strait Solid, whose two Bases or Ends, are equal, parallel, a-like, and a-like situate.

2. A Prism, takes its Sir-Name from its Base; as a Round Prism, a Triangular, a Quadrangular, or a Multangular Prism, all are measured by this one General Rule.

As 1 .. Area of one Base :: Length .. Solid Content.

Examp. 1. A Round Prism, call'd by some a Cylinder, whose Diameter at each End is _____ 21 } Inches.
And Length is _____ 30 }

What's the Solid Content? *Answ.* 10392 Inches.

A Cylinder's two Bases are two equal Circles, and therefore the Area of its Base is found by Prob. 30. to be Inches 346.4 Tenths: Then it is,

As 1 .. 346.4 :: 30 .. 10392 Inches, the Solid Content req.

Examp. 2. An Elliptic Prism, whose Bases are equal Ellipsis, their

Transverse } Diameter is $\left\{ \begin{smallmatrix} 12. \\ 8. \end{smallmatrix} \right\}$ Inches given.
Conjugate }

Length of the Solid is _____ 30.

What's the Solid Content? *Answ.* Inches 2262.

For

For its Base being an Ellipsis, the Area by *Prob. 27* is Inches 75.4, and then it is,

As $1 \dots 75.4 :: 30 \dots 2262$ Inches the Solid Content required.

Examp. 3. A Triangular Prism, whose Bases are two equal Triangles, in each of which

The $\left\{ \begin{array}{l} \text{Base} \text{---} \text{---} \text{---} \\ \text{Perpendicular} \end{array} \right\}$ is $\left\{ \begin{array}{l} 16. \\ 12. \end{array} \right\}$ Inches given.

And the Length of the Solid is 20 Inches.

What's the Solid Content? *Answ.* Inches 1920.

The Area of the Base (by *Prob. 24*) in Page 22, is 96 Inches: and then it's,

As $1 \dots 96 :: 20 \dots 1920$ Inches, Solid Content required.

Examp. 4. A Cube (which is a Quadrangle Prism, of equal Length, Breadth and Depth, being cloathed with six equal Squares) each Side being Inches 12: What's the Solid Content? *Answ.* Inches 1728.

For, As $1 \dots \text{Square of } 12 :: 12 \dots 1728$: That is, the Extent from 1 to 12, turned over two times from 12, reacheth to Inches 1728 the Solid Content required.

Examp. 5. A Parallelepipedon, or a Quadrangle Prism, whose Bases are two equal Squares, of each, one

Side $\left\{ \begin{array}{l} \text{is Feet } 1.25 \\ \text{Length } 21.75 \end{array} \right\}$ Parts of 100 given.

What's the Solid Content? *Answ.* Feet 33.9 Tenths.

For, As $1 \dots \text{Square of } 1.25 :: 21.75 \dots \text{Feet } 33.9$: that is, the Extent from 1 to 1.25, being turned two times from 21.75 will reach to 33.9, the Solid Content required.

Examp. 6. A Parallelepipedon, or a Quadrangle Prism, whose Bases are two equal Long-squares, in each,

The $\left\{ \begin{array}{l} \text{Breadth is } 1.6 \\ \text{Depth is } 2.5 \end{array} \right\}$ Feet given.

And Length of the Solid 15.5

What's the Solid Content? *Answ.* Feet 62.

For it is, As $1 \dots 1.6 :: 2.5 \dots 4$ Feet, the Area of the Base.

Then, as $1 \dots 4 :: 15.5 \dots 62$ Feet, Solid Content required.

In the like manner may the Solid Content of any Prism be found, let its Base be of what Form soever; for its Area may be found by *Prob. 20, 21, 22, 23, 24, 25, 26, or 27*, and the Solid Content of the Prism, by the general Rule in *Problems* the 31st.

Prob.

Prob. XXXII. *The Dimensions of a Pyramid given; to find the Solid Content.*

Definitions. 1. A *Pyramid* is a strait Solid, having one Base, and t'other End a Punct, called the Vertex.

2. A *Pyramid*, takes its Sir-name from its Base, as a Round, an Elliptic, a Triangular, a Quadrangular, or a Multangular Pyramid; all are measured by this one General Rule.

As 3 .. Area of Base :: Length .. Solid Content.

Note; By Length understand a Perpendicular from the Vertex to the Base, and not the Length of the Pyramid on its Surface or outside from Vertex to Base.

Examp. A Round Pyramid, called by some a Cone, whose Diameter at Base—21 { Inches given,
Perpendicular Length 30 }

What's the Solid Content? *Answ.* 3465 Inches.

For the Area of the Base is Inches $346 \frac{1}{2}$ by *Prob.* 20. And,

Then; As 3 .. 346.5 :: 30 .. 3465 Inches, which is the Solid Content required.

The like do for any other Pyramid, which I pass over, having given six Examples in a Prism, and leave you to apply them here.

Prob. XXXIII. *The Dimensions of a Prismoid given; to find its Solid Content.*

Definition. 1. A *Prismoid* is a strait Solid having two unequal Bases or Ends, but are parallel, like, and a-like situate.

2. A *Prismoid*, is as various as a Prism, and is no other than the Frustum of a Pyramid.

3. *Frustum of a Pyramid*, is the lower Part of it, when the upper part is cut off parallel to the Base; and all of them may be measured by this General Rule.

1. Multiply the Area of each Base together, and from the Product extract the Square Root.

2. Add the Area of each Base and that Square Root into one Sum; Then,

3. Say, As 3 .. that Sum :: Length .. Solid Content.

But for a *Square Prismoid*, take this particular Rule.

1. To the Square of each Side, add the Product of the sides into one Sum: Then,

Say, As 3 .. that Sum :: Length .. Solid Content.

And for a *Round Prismoid*, this is the Rule.

1. Add

What's the Solid Content? *Ans.* 1717.4 Inches. For,

As 1 .. $\left\{ \begin{array}{l} 5. \\ 5.8 \end{array} \right\} :: \left\{ \begin{array}{l} 7.5 \\ 8.7 \end{array} \right\} .. \left\{ \begin{array}{l} 37.5 \text{ Area of Top Long Square,} \\ 50.46 \text{ Area of Bottom Ditto.} \end{array} \right.$

As 1 .. 37.5 :: 50.46 .. 1892.25 whose Square Root is — 43.5

Area at Top — 37.5

Area at Bottom — 50.46

Sum is — 131.46

Then; As 3.82 .. 131.46 :: 47 .. 1717.4 Inches is the Solid Content required.

If the Bases of the forefaid Prismoid had been long Squares the Work is the same, except only in the last Proportion; and having the same Dimensions, its Solid Content is Inches 2060, very near, for it is thus;

As 3 .. 131.46 :: 47 .. 2059.5 Inches the Solid Content.

Prob. XXXIV. *The Dimensions of a Pyramidoid given; to find it's Solid Content.*

Definition 1. A Pyramidoid is not a strait Solid, it hath one Base, and t'other End a Punct call'd the Vertex, but the outside from Base to Vertex, is convex, either Spheriodic, Parabolic, or Hyperbolic, &c.

2. A Pyramidoid, takes its Sir-name from its Base and outside; as a Spheriodic, Parabolic, or Hyperbolic Round Pyramidoid; and so of the rest, as in a Pyramid; all may measured by this one General Rule.

As 1.5 .. Area of the Base :: Length .. Solid Content, when a Spheriodic Pyramidoid; but if

$\left. \begin{array}{l} \text{Parabolic} \\ \text{Hyperbolic} \end{array} \right\} \text{The first Term is } \left\{ \begin{array}{l} 2. \\ 2.4 \end{array} \right.$

Examp. A Round Pyramidoid, called by some a Conoid, whose

Diameter at the Base — 21 } Inches
Perpendicular Length — 30 }

What's the solid Content, if $\left\{ \begin{array}{l} \text{Spheriodic?} \\ \text{Parabolic?} \\ \text{Hyperbolic?} \end{array} \right\} \text{Ans. } \left\{ \begin{array}{l} 6930 \\ 5197.5 \\ 4331.2 \end{array} \right.$

The Area of the Base is Inches 146.5 Tenths, by *Prob.* 20.

And then it's,

As $\left\{ \begin{array}{l} 1.5 \\ 2. \\ 2.4 \end{array} \right\} .. 146.5 :: 30 .. \left\{ \begin{array}{l} 6930 \text{ Spheriodic} \\ 5197.5 \text{ Parabolic} \\ 4331.2 \text{ Hyperbolic} \end{array} \right\} \text{Solid Cont. in Inches.}$
More

More Examples I think here needless, having given so many in a Prism, and the Rule for this and that being so alike.

Prob. XXXV. *The Dimensions of the Frustum of a Parabolic Pyramidoid given; to find the Solid Content.*

Definition. *Frustum*, is the lower Part of a Pyramidoid, cut parallel to its Base.

A General Rule.

* This is the same with the General Rule for a Prismoid, save only in the third Precept, which in this Case is thus,

As 2 .. that Sum : : Length .. Solid Content required.

But for the Frustum of a Square Parabolic Pyramidoid take this particular Rule.

1. To the Square of the greatest side, add the Square of the least Side into one Sum : Then,

2. Say, As 2 .. that Sum : : Length .. Solid Content requir'd.

And for a Round Frustum, that is Parabolic, the Rule is ;

1. Add the Square of each Diameter into one Sum ; Then,

2. Say as 2.546 .. that Sum : : Length .. Solid Content.

Or more largely thus ; As 2.54649, is to the foresaid Sum ; so is the Length to the Solid Content.

Example 1. The Frustum of a Square Parabolic Pyramidoid, whose

Side at Top ————— }
 Side at Bottom ————— } is Inches { $\begin{matrix} 4 \\ 6 \\ 48 \end{matrix}$ } given.
 Perpendicular Length ————— }

What's the Solid Content ? *Ans.* 1824 Inches.

For ; As 1 .. 4 : : 4 .. 16 the Square at Top.

As 1 .. 6 : : 6 .. 36 the Square at Bottom.

As 1 .. 4 : : 6 .. 24 the Product of the two Sides.

Sum of the 2 Squares 76 Inches, and the Product of the two Sides.

Then say ; As 2 .. 76 : : 48 .. 1824 Inches, the Solid Content.

Examp. 2. The Frustum of a Round Parabolic Pyramidoid, (or the Frustum of a parabolic Conoid) whose

Diameter at Top ————— }
 Diameter at Bottom ————— } Inches given.
 Perpendicular Length ————— }

What's it's Solid Content ? *Ans.* 1433 Inches.

For

For ; As 1 .. 4 :: 4 .. 16 the Square at Top.

As 1 .. 6 :: 6 .. 36 the Square at Bottom.

As 1 .. 4 :: 6 .. 24 the Product of both Diameters.

Sum of the two Squares 76 Inches, the Product of both Diam.

Then say ; As 2,546 .. 76 :: 48 .. 1433 Inches, the Solid Content.

Sect. V. *The Application of the whole, in measuring Board, Glass, Plastering, Painting, Paving, and Land; Timber and Stone; Gauging of Cask, and a Ship's Hold.*

1. **B**oard or Plank, Glass, and flat Stone, are measured by the Foot Square, or Superficial Foot, containing 144 Square Inches, or 12 times 12 : So that to know how many Square Feet are contained in the Area, or Content of any Superficies taken in Inches, the Proportion is this :

As 144 .. 1 :: Content in Inches .. Content in Feet.

But the easiest way, is to have the Foot of 12 Inches divided Decimally into 100 Parts, called Foot Measure ; and by such a Foot to take the Dimensions of the thing you would measure, or know the Content of in Feet.

Then consider, if the thing to be measured be a Circle, Triangle, Square, Long-square, &c. the Rules proper for such a Figure (in Sect. 3. of this Chapter) direct to find the Area. That is,

If the thing to be measured be a Circle, then *Prob. 20* or *21* sheweth how to find its Area ; if it's a Triangle, then *Prob. 24* gives a Rule to find the Area ; if a Parallelogram *Prob. 25* hath a Rule to find its Area, whether it be a Square, a Long-square, a Rhombus, or Rhomboide ; now Floors and Ceilings of Houses are generally Squares, or Long-squares ; also Boards, Planks and flat Stones, are (commonly) Squares or Long-squares : If a Trapezia, then *Prob. 26* sheweth how to measure it ; if it be an Ellipsis, *Prob. 27* hath a Rule for its measuring ; and such are oval Tables. And if the thing to be measured be a Parabola, then *Prob. 28* sheweth how to find its Area.

4. *Plastering, Painting, and Paving*, is measured by the Yard Square. containing nine Square Feet ; and therefore after you have found the Content in Feet ; the Proportion is this ;

As 9 .. 1 :: Content in Feet .. the Content in Yards.

3. **T**imber is measured by the Cubic Foot, containing 1728 Solid

Solid Inches: And when the Content of any Solid Body is known in Cubic Inches, to reduce them into Cubic Feet, which is the Timbet, or Stone Foot, the Proportion is this;

As 1728 .. 1 :: Cubic Inches .. Solid Feet.

But measuring the Dimensions of a Solid, by the aforesaid Decimal Foot, the Rules proper for it (in *Seet. 3.* of this *Chap.*) as a Sphere, Prism, &c. Finds the Solid Content in Feet.

That is, if it be a Sphere, then *Prob. 29* hath a Rule to find its Solid Content, such are Bullets, and Granadoes used in great Guns, Mortars or Bombs.

If a Spheriod, then *Prob. 30* sheweth the measuring of it, and such are things in shape like an Egg, whose Ends are equal.

If a Prism, then *Prob. 31* directs its Measurement, and by it, all strait pieces of Timber or Stone, whose Ends are alike and equal, are measured.

If a Pyramid, then *Prob. 32* shews the measuring it, and such are Spire Steeples, and all Strait Solids ending in a Point at one End.

If a Prismoid, then *Prob. 33* sheweth its Measuring, and such is all Taper Timber, whether Round or Square.

If a Pyramidoid, then *Prob. 34* sheweth the Measuring of it, and such is the half of all Casks, if they were continued from the Bung by the Head, till they end in a Point.

If a Fruustum of a Parabolic Pyramidoid, then *Prob. 35* serves to measure it, and such are close Casks, if cut in halves through the Bung, and parallel to each Head; so that by this Problem is taught the way of finding the half Content of a Cask, whose double is the whole Solid Content: But a more particular Rule for gauging a Cask, followeth in the next Problem.

4. Land is measured by the Rod or Pole, containing in Length, Feet 16½, and a Square Rod is Feet 272¼; an Acre of Land containing 160 Square Rods.

Now the readiest way to cast up the Content of Land in Acres, is to take the Dimensions by a Four Pole Chain, Decimally divided; (that is into 100 Links) then the Rules (in *Seet. 3.* of this *Chap.*) proper to the Form of it, (whether a Triangle, Square, Long-square, Rhombus, Rhomboide, or Trapezia,) finds the Content in Square Chains; which are turned to Acres thus;

As 10 .. 1 :: Square Chains .. Content in Acres.

5. Gauging

5. Gauging is by the Gallon, and that either Beer, containing 282 Cubic Inches, or Wine 231 : Then to reduce Cubic Inches into Gallons of either Kind, the Rule is;

As $\left\{ \begin{smallmatrix} 282 \\ 231 \end{smallmatrix} \right\} \dots 1 :: \text{Cubic Inches} \dots \text{Gallons of } \left\{ \begin{smallmatrix} \text{Beer.} \\ \text{Wine.} \end{smallmatrix} \right.$

So that the Dimensions of any Solid Body taken in Inches, the proper Rules for that Body, finds its Content in Inches, and the Rule above finds the Gallons of Beer, or Wine it will hold.

Prob XXXVI. 6. To Gauge a Cask, taken, at the middle Frustum of a Spheroid.

The Rule. 1. Add twice the Square of the Bung-Diameter, and once the Square of the Head, into one Sum. Then say,

2. As 3.82 .. that Sum :: Length .. Solid Content of the Cask in Inches; and then the Gallons of Beer, or Wine are found by the foregoing Rule. Or thus,

1. Say, As 1 .. 0.7 :: Difference of Head and Bung .. a Fourth Number.

2. That 4th Number add to the Head Diameter, the Sum is a Mean Diameter: Then say,

As $\left\{ \begin{smallmatrix} 18.95 \\ 17.15 \end{smallmatrix} \right\} : \text{Sq. Mean. Diam.} :: \text{Length} \dots \left\{ \begin{smallmatrix} \text{Beer} \\ \text{Wine} \end{smallmatrix} \right\} \text{Gallons}$

Exam. A Cask whose Bung Diameter is 23.

Head Diameter ————— 19.9 } Inches given

Length of the Cask ————— 27.4 }

What's the Content thereof in Beer, or Wine Gallons?

Ans^w. Beer Gallons 36.99, or Wine Gallons 45.5.

As 1 .. 0.7 :: 3.1 .. 2.17, which added to 19.9; makes the Mean Diameter to be 22.07. Then,

As $\left\{ \begin{smallmatrix} 18.95 \\ 17.15 \end{smallmatrix} \right\} \dots \text{Square } 22.07 :: 27.4 \dots \left\{ \begin{smallmatrix} 36.99 \text{ Beer} \\ 45.5 \text{ Wine} \end{smallmatrix} \right\} \text{Gallons}$

That is; the Extent from the First Term to the Second, twice turned over from the Third, gives the Gallons required.

Prob. XXXVII. 7. To measure a Ship, that is, to find her Tonnage.

The Rule. 1. Say as 1 .. Breadth; . Half Breadth .. Fourth Number.

C

2. Then

2. Then; As 94 .. 4th Number :: Length .. Tuns required.

Examp. A Ship 75 Feet by the Keel, and 23 Feet by the Beam: What's her Tunnage? *Ans.* 211 Tuns.

For, As 1 .. 23 :: 11.5 .. 264.5, the 4th Number.

Then, As 94 .. 264.5 :: 75 .. 211 Tuns required.

8. To measure Bales or Cases, or to give the Tunnage, of them; they are Prisms, and their Dimensions taken by the Decimal Foot; the Content in Cubic Feet is found by Prob.

31. And then say,

As 66 .. 1 :: Cubic Feet .. Tuns required.

Or thus, As 66 .. Area Base :: Length .. Tuns required.

Examp. A Bale whose $\left\{ \begin{array}{l} \text{Breadth} \\ \text{Depth} \\ \text{Length} \end{array} \right\}$ is Feet $\left\{ \begin{array}{l} 4.2 \\ 2.6 \\ 5.7 \end{array} \right\}$ given.

What's the Content in Tuns? *Ans.* 0.943 Parts. For

As 1 .. 4.2 :: 2.6 .. 10.92 Area of its Base: Then,

As 66 .. 10.92 :: 5.7 .. Tuns, 0.943 Parts required.

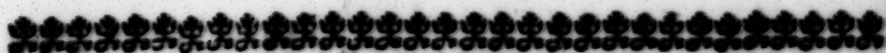
Note, That 66 Feet is the Content of a Case that incloseth two English Butts, so that this Rule includes the Cantlings of the Cask, which is better than $\frac{1}{3}$ part; therefore allowing the Cantlings or Vacancy to be 26 Feet, the remaining 40 Feet is to be counted for a Tun: And then,

Then will the foresaid Bale contain Tun 1.556 parts. For,

The Rule is, As 40 .. Area Base :: Length .. Tuns required

As 40 .. Area Base 10.92 :: Length 5.7 .. Tun 1.556 parts.

So much for Geometry; Trigonometry is next in order to be learned.



Chap. II. Containing the Doctrine of Plain Triangles.

Trigonometry, is that part of Geometry, which treats more particularly about the measuring of Triangles, wherein having three things given; either Sides, Angles, or both; a 4th (Side or Angle) may be found; and is either Plain or Spheric; It's the former we begin with.

Section I. *Of Things necessary to be understood, relating to Plain Trigonometry.*

1. **A** *Trirangle*, is any Three-corner'd Figure; it consisteth of six things, Three Sides and Three Angles, and is either Plain or Spheric.

2. A *Plain Triangle* is projected on a Plain or Flat Superficies, and therefore its Sides are Right-lines: But the Sides of a *Spheric Triangle*, are Arks of the Sphere, of which, more in the Chapter of *Spheric Trigonometry*.

3. An *Angle* is the meeting of any two Lines, making a Corner; and is either a *Right-angle*, containing just 90 deg. or *Oblique* more than 90 deg. called an *Obtuse-angle*; or less than 90 deg. called *Acute-angle*.

4. When two Lines crossing one another, make the Angles on every side equal, than those Angles are *Right*, and the Lines are *Perpendicular*.

5. A *Degree*, is the 360 part of the Periphery of any Circle; and the 4th Part, 90, is called a *Quadrant*, and the half 180, is a *Semicircle*; Also a *Degree* containeth 60 Min. and a Min. 60 Secods, &c. as in Prob. 9. Defin. 1 of *Geometry*, in page 15.

6. By *Complement* of any Number of Degrees, understand what those Degrees want of 90.

7. A *Triangle*, is either *Right-angled*, having one *Right-Angle*; or *Oblique*, having no *Right-Angle*.

8. In a *Right-angle Triangle*, the Side opposite to the *Right-angle*, is called the *Hypotenuse*, and the two Sides containing the *Right-angle*, are called *Legs*.

In all *Plain Triangles*, the Sum of the three Angles added together, are equal to 180 Degrees.

10. The Angles (of a *Plain Triangle*) being only given, the Proportion of the Sides can only be determined; therefore,

11. In a *Right-angle Triangle*, two things given (if one be a Side) are sufficient to find a Third: But,

12. In *Oblique Triangles* three things, and one of them a Side, must be given, to find a Fourth.

13. Three Letters signify an Angle; as BAC signify the Angle A: And Two Letters a Side; as AB signify the Side AB, &c.

14. Given Things, whether Sides or Angles, are marked with a *Dash*, thus, (') and required things, with a *Cypher*, thus, (°),

15. $\left. \begin{array}{l} \text{d.} \\ \text{m.} \end{array} \right\}$ after any Number signifies $\left\{ \begin{array}{l} \text{Degrees,} \\ \text{Minutes,} \end{array} \right\}$ thus
 25d. is 25 Degrees, and 31m. is 31 Minutes.

S.	{	stands for	Sine.
S. c.			Sine Complement, or Co-Sine,
T.			Tangent.
T. c.			Tangent Complement, or Co-Tang.
Sec.			Secant.
Sec. c.			Secant Complement, or Co-Secant.
Co. Ar.			Complement Arithmetical.
..			is to, or to the
::			so is ; As thus, 2 .. 4 :: 3 .. 6.

That is, As 2 is to 4, so is 3 to 6.

16. There are seven Cases in Right angle Triangles, and Six in Oblique. Their Solution follows; but first of Right-angle Triangles.

Section II. *The first Axiom, and the seven Cases of Plain Right-angle Triangles depending thereon.*

Axiom 1. IN all Plain Right-angle Triangles, if one of its Sides be made Radius, the other two will be either Sines, Tangents, or Secants; That is,

1. If the Hypotenuse be Radius, each Leg is the Size of its opposite Angle, See Plate 2. Fig. 1. for the first Axiom.

2. If one Leg be Radius, the Hypotenuse is Secant, and the other Leg is Tangent of the Angle opposite to this Leg. See Plate 2. Fig. 2. for the first Axiom.

And what Proportion the Side made Radius, hath to Radius; the same hath the other Sides, to the Sines, Tangents, or Secants by them represented; and the contrary. And,

Note 1. To find a Side, any Side may be Radius, saying thus;

As the Word on the Side given, is to the Side given;

So is the Word on the Side required, to the Side required.

Note 2. To find an Angle, one of the given Sides must be Radius. Then say,

As one given Side, is to the Word on it;

So is the other given Side, to the Word on it.

Observe to begin with the Side made Radius.

These two Notes (to the diligent Reader) are sufficient to frame any Proportion by the first Axiom, making any Side of a Right-angle Triangle the Radius.

Prob. I.

Problem I. Case 1. *The Angles, and Hypotenuse given; to find either of the Legs.*

Examp. In the Right Angle Triangle ABC Plate 2. Fig. 1.

The $\left\{ \begin{array}{l} \text{Hypot. AC } 121 \text{ Leag.} \\ \text{Angle BAC } 54^{\circ} 30' \end{array} \right\}$ given : Leg. $\left\{ \begin{array}{l} \text{AB} \\ \text{BC} \end{array} \right\}$ required

This Triangle is made by Prob. 10 of Geometry, in p. 17.

If you make the Hypotenuse AC Radius, the Proportion (by Axiom 1. and Note 1.) is thus,

As Radius, is to the Hypotenuse AC; so is the Sine of the Angle BAC, to the Leg BC. Or thus briefly;

Radius .. Hypot. AC :: S. BAC .. Leg BC.

S. 90d. — 121 Leag. 54d. 30m.

9.910686

2.082785

Leag.

11.993471 | 98.51 parts.

To work Proportions by Logarithms, observe this General Rule. Add the Logarithm of the Second and Third Term together; and from that Sum subtract the Logarithm of the first Term, the Remainder is the Logarithm of the fourth Term, or Number sought.

As in the foregoing Proportion, the Sum of the Logarithms of the Second and Third Term added together is 11.993471; from which it is easy to Subtract the Logarithm of the First Term (being Radius) by cancelling (cutting off, or leaving out) the first Figure to the Left-hand, and then it is 11.993471, which brings forth 98.51; that is, Leagues 98.51 Parts of 100 for the Leg BC, the fourth Term, or Side required.

By Gunter's Scale, thus.

Radius .. AC :: S. BA. C .. BC That is,
S. 90d. .. 121 Leag. :: S. 54d. 30m. .. Leag. 98.5 Tenth.

That is to say, the Extent from Sine 90d. (on the Line of Sines) to 121 Leagues (on the Line of Numbers) will reach from Sine 54d. 30m (on the same Sines) to Leagues 98.5 Tenth, (on the Line of Numbers) for the Leg BC, nearly as above.

Observe the like in all that follows, except in those Proportions wherein is the Word Secant, which is wrought only by the Logarithms.

The three several Proportions making each Side Radius, to find the Leg BC, are these which follow.

C 3

.Radius

Radius .. S.BAC }
 Sec. BAC .. T.BAC } :: Hypotenuse AC .. Leg BC.
 Sec. ACB .. Radius }
 Likewise to find the Leg AB, they are these following.
 Radius .. S.ACB }
 Sec. BAC .. Radius } :: Hypotenuse AC .. Leg AB.
 Sec. ACB .. T.ACB }

Note ; When Radius is not the first Term in the Proportion, then take the Complement-Arithmetic of the Logarithm of the first Term ; (which how to find is shew'd in Chap. 1. Sect. 2. Proposition 9. of the Use of the Table of Sines, Tangents and Secants, in Page 300.) This Comp. Arith. or Co. Ar. add to the Logar. of the Second and Third Terms, and from the Characteristic of their Sum subtract 10 or 20, the remaining Figures is the Logarithm of the Fourth Term sought ; as may be seen in the following Proportion in Problem II.

Prob. II. Case 2 and 3. *The Angles and one Leg given ; to find the Hypotenuse, and the other Leg.*

Exam. In the Right-Angle Triangle ABC. Plate 2. Fig. 2.
 The { Ang. ACB 35d. 30m. } given : { Hyp. AC } requi.
 { Leg. BC 98 Leagues } { Leg AB }

This Triangle is made by Prob. 12. of Geometry, P. 17 & 18.

1. To find the Hypotenuse AC, make it Radius, and the Proportion (by *Axiom* 1. and *Note* 1.) is thus ;

As the Sine of the Angle BAC, is to the Leg BC ; so is Radius, to the Hypotenuse AC. Or thus,
 S.BAC .. Leg. BC :: Radius .. Hypotenuse AC.

54d. 30m. 98 Leg. —————
 10.000000
 1.091226
 Co. Ar. 0.089314
 ————— (Leag.
 12.080540 (120.4

By Gunter's Scale thus ;

S.BAC .. Leg BC :: Radius .. Hypotenuse AC. That is,
 S. 54d. 30m. .. 98 Leagues :: S. 90d. .. Leag. 120.4 Tenths.
 That is, the Extent from Sine of 54d. 30m. (on the Line of Sines) to 98 Leagues, (on the Line of Numbers) will reach from Sine 90d. to Leag. 120.4 Tenths, the Hypotenuse required.

The

The three several Proportions, making each side Radius, to find the Hypotenuse, are these following.

$$\begin{array}{l} \text{S. BAC} \dots \text{Radius} \\ \text{T. BAC} \dots \text{Sec. BAC} \end{array} \left. \vphantom{\begin{array}{l} \text{S. BAC} \dots \text{Radius} \\ \text{T. BAC} \dots \text{Sec. BAC} \end{array}} \right\} :: \text{Leg BC} \dots \text{Hypotenuse AC.} \\ \text{Radius} \dots \text{Sec. ACB}$$

And to find the Leg AB, they are these;

$$\begin{array}{l} \text{S. BAC} \dots \text{S. ACB} \\ \text{T. BAC} \dots \text{Radius} \\ \text{Radius} \dots \text{T. ACB} \end{array} \left. \vphantom{\begin{array}{l} \text{S. BAC} \dots \text{S. ACB} \\ \text{T. BAC} \dots \text{Radius} \\ \text{Radius} \dots \text{T. ACB} \end{array}} \right\} :: \text{Leg BC} \dots \text{Leg AB.}$$

Note; In working by *Gunter*, when a Tangent is mentioned, the Radius then is the Tangent of 45d. as in the two last Proportions, it is;

As T. BAC .. Radius :: Leg BC .. Leg AB. Which is, T. 54d. 30m. .. T. 45d. :: 98 Leag. .. Leag. 69.8 Tenths, That is, the Extent from 54d. 30m. to 45d. (on the *Line of Tangents*) will reach from 98 Leagues, to Leagues 69.8 Tenths on the *Line of Numbers*, for the Leg. AB.

As Radius .. T. ACB :: Leg BC .. Leg AB. Which is, T. 45d. .. T. 35d. 30m. :: 98 Leag. .. Leag. 69.8 Tenths.

That is, the Extent from T. 45d. to T. 35d. 30m. will reach from 98 Leagues, to Leag. 69.8 Tenths, as before.

Prob. III. Case 4 and 5. *The Hypotenuse and one Leg given; to find the Angles and the other Leg.*

Examp. In the Right Angle Triangle ABC. Plate 2. Fig. 3.

The $\left\{ \begin{array}{l} \text{Hyp. AC } 121 \\ \text{Leg AB } 69 \end{array} \right\}$ Leagues given: $\left\{ \begin{array}{l} \text{ACB or BAC} \\ \text{and Leg BC.} \end{array} \right\}$ req.

This Triangle is made by *Prob. 11. of Geometry, Page 17.*

1. To find the Angles.

If you make the Hypotenuse AC Radius, the Proportion (by *Axiom 1. and Note 2.*) is thus;

As the Hypotenuse AC, is to Radius; so is the Leg AB, to the Sine of the Angle ACB. or thus;

$$\text{Hypot AC} \dots \text{Radius} :: \text{Leg AB} \dots \text{S. ACB.}$$

$$121 \text{ Leag.} \dots 90d. :: 69 \text{ Leag.} \dots \text{S. } 34d. 46m. \text{ Which subtract from } \text{---} \text{---} \text{---} 90d. 00m.$$

Remainder is Angle BAC $\text{---} 55d. 14m.$ by the 9th of *Section 1. of this Chapter in Page 35.*

And if the Leg AB is Radius, then the Proportion (by *Axiom 1. and Note 2.*) is thus.

As the Leg AB, is to Radius; so is the Hypotenuse AC, to the Secant of the Angle BAC. Or thus,

AB 69 Leag. :: Radius :: AC 121 Leag. :: Sec. BAC 55d. 14m.

Note; This Proportion is not wrought on the Gunter because of the Word *Secant* in the 4th Term; but being wrought by the *Tables* (as before directed) will produce the Angle BAC 55d. 14m. as above; which subtracted from 90d. gives 34d. 46m. for the Angle ACB, as before.

2. The Leg BC may be found by the 1st or 2d Case several Ways: As thus,

Radius	.. AC :: S. BAC	} .. BC Leagues 99.4 Tenths.
S. ACB	.. AB :: S. BAC	
Sec. BAC	.. AC :: T. BAC	
Radius	.. AB :: T. BAC	
Sec. ACB	.. AC :: Radius	
T. ACB	.. AB :: Radius	

Prob. IV. Case 6 and 7. *The Legs given; to find the Angles, and Hypotenuse.*

Examp. In the Right-angle Triangle ABC. *Plate 2. Fig. 4.*

The Leg $\begin{cases} AB \ 98 \\ BC \ 69 \end{cases}$ Leag. given: $\begin{cases} \text{Angle BAC or ACB} \\ \& \text{Hypotenuse AC} \end{cases}$ req.

This Triangle is made by *Prob. 13 of Geometry.*

1. Make the Leg AB Radius, and the Proportion (by *Axiom. 1.* and *Note 2.*) is thus;

As the Leg AB, is to Radius; so is the Leg BC, to the Tangent of the Angle BAC. Or thus,

Leg AB .. Leg BC :: Radius .. T. BAC.

98 Leag. .. 69 Leag. :: T. 45d. .. T. 35d. 09m. which
Subtract from _____ 90d. 00m.

The Remainder is _____ 54d. 51m. the Angl.

ACB, by the 9th of *Section 1.* of this *Chapter*, in *Page 35.*

And if the Leg BC be made Radius, the Proportion is thus;

Leg BC .. Leg AB :: Radius .. T. ACB.

69 Leag. .. 98 Leag. :: T. 45d. .. T. 54d. 51m. as before,

Which being subtracted from 90, leaveth 35d. 09m. for the Angle BAC. Either of these Proportions is sufficient to find both Angles.

2. The Hypotenuse AC may be found (by the 2d Case) several Ways.

First

Sect. II. Plain Trigonometry Rectangular.

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First, Making the Hypotenuse AC Radius; thus,
 $S.BAC \dots BC \} :: \text{Radius} \dots \text{Hypotenuse } AC.$
 $S.ACB \dots AB \}$

Secondly, making the Leg AB Radius, thus,

$\text{Radius} \dots AB \} :: \text{Sec. } BAC \dots \text{Hypotenuse } AC.$
 $T.BAC \dots BC \}$

Thirdly, making the Leg BC Radius; thus,

$\text{Radius} \dots BC \} :: \text{Sec. } ACB \dots \text{Hypotenuse } AC.$
 $T.ACB \dots AB \}$

These 6 Proportions, if the Learner works them, he'll find them all to produce Leagues 119.8 for the Hypotenuse AC.

Note; The 5th and 7th Cases may be perform'd by the 47th Proposition of the *First Book of Euclide's Elements*, which proves the Square of the Hypotenuse, is equal to the Sum of the Squares of the two Legs; Therefore,

1. By Natural Arithmecic, Extracting the Square Root; the Rules are these,

First, In the 5th Case to find a Leg; when the Hypotenuse, and one Leg is given; Thus,

The Square Root of the Difference of the Squares of the Hypotenuse and one Leg, is the other Leg.

Secondly, In the 7th Case to find the Hypotenuse, when both the Legs are given; thus,

The Square Root of the Sum of the Squares of both Legs, is the Hypotenuse.

2. By Logarithms in these two Rules following.

First Rule. When the Hypotenuse, and one Leg is given, to find the other Leg; thus,

Half the Sum of the Logarithms of the Sum, and Difference of the Hypotenuse, and given Leg; is the Logarithm of the Leg required.

Second Rule. When both Legs are given, to find the Hypotenuse, it is thus,

From the double Logarithm of the greater Leg, subtract the Logarithm of the lesser Leg; the absolute Number answering to it, add to the lesser Leg; half the Sum of the Logarithms of that Sum, and lesser Leg, is the Logarithm of the Hypotenuse required.

Examp.

Examp. 1. The Hypotenuse AC 121 Leagues, and the Leg AB 69 Leagues: What is the Leg BC by the Square Root?

Hypotenuse AC	121	And Leg AB	69
	121		69
	121		621
	242		414
	121	Square of AB is	4761

Square of AC is 14641

Square of AB is 4761

Diff. of the Squares is 9880 (99.39 is the Leg BC.)

189)1780

1701

1983)7900

5949

19869)195100

178821

Remainder is 16279

So that the Leg BC is Leagues 99.39 Parts of 100.

By Logarithms, thus.

The Hypotenuse AC 121 Leagues.

The given Leg AB 69 Leagues.

Sum of AC and AB 190 its Logarithm is 2.278754

Difference of AC and AB 52 its Logarithm is 1.716003

The Sum of the Logarithm is 3.994757

The half Sum of these Logarithms 1.997378

Whose absolute Number is 99.39; that is, Leagues 99.39 Parts of 100 is the Leg BC, the same as before.

Examp. 2. The Leg AB is 98 Miles, and the Leg BC 69 Miles given: What is the Hypotenuse AC? by the Square Root.
The

Sect. II. *Plain Trigonometry Oblique.* 43

The Leg AB	98	And Leg BC	69
	98		69
	<u>784</u>		<u>621</u>
	882		414
Square of AB is	9604	Square of BC	4761
Square of BC is	4761		
Sum of the Squares is	14365	119.8 that is 119 Leagues $\frac{1}{2}$	
	1	is the Hypotenuse AC.	
	<u>21) 043</u>		
	21		
	<u>229) 2265</u>		
	2061		
	<u>2388) 20400</u>		
	19104		
Remainder is	1296		

By Logarithms, thus,

The greater Leg AB 98, its Logarithm is	1.991226
Multiply its Logarithm by	2
The Double Logarithm of the Leg AB is	3.981452
The lesser Leg BC 69 Miles, its Logarithm is	1.838849
Absolute Number 139.2 answering the Logar.	2.143603
Sum is 208.2 its Logarithm is	2.318481
The lesser Leg BC 69 Miles, its Logarithm is	1.838849
The Sum of the two last Logarithms is	4.157330
The half is the Logarithm of AC 110 $\frac{1}{2}$ required	2.078665

Section III. *Three other Axioms, with the five Cases of Oblique Plain Triangles thereunto belonging.*

Axiom 2. IN all Plain Triangles, the Sides are in such Proportion one to another, as are the Sines of their opposite Angles. That is,

1. As the Sine of any one Angle, is to its opposite Side; so is the Sine of any other Angle, to its opposite Side.
2. As a Side, is to the Sine of its opposite Angle: so is a Side, to the Sine of its opposite Angle.

Note; To find a Side, begin with an Angle; but to find an Angle, begin with a Side. From

From this *Axiom* are drawn the Proportions for the First, Second, and Third Cases following.

Prob. V. Case 1. *Of Obliquangles. Two Angles, and one Side given ; to find either of the other sides.*

Example. In the Oblique Triangle BDC. *Plate 2. Fig. 5.*
 The $\left\{ \begin{array}{l} \text{Angle} \\ \text{Side} \end{array} \right\} \left\{ \begin{array}{l} \text{BDC } 101^{\circ} 25' \\ \text{CBD } 44^{\circ} 42' \\ \text{BC } 76 \text{ Yards} \end{array} \right\} \text{ given : Side } \left\{ \begin{array}{l} \text{CD} \\ \text{BD} \end{array} \right\} \text{ and } \left\{ \begin{array}{l} \text{req.} \end{array} \right\}$

This Triangle is made by *Prob. 14. of Geometry*, in Pages 18 and 19.

1. The Proportion according to the Second Axiom for finding the Side CD, is this ;

As the Sine of the Angle BDC, is to the Side BC ; so is the Sine of the Angle CBD, to the required Side CD. Or thus ;
 $S. BDC \dots Side BC :: S. CBD \dots Side CD \text{ required.}$

$S. 101^{\circ} 25' \dots 76 \text{ Yards} :: S. 44^{\circ} 42' \dots Yds. 54.5 \text{ Tenths.}$
 180° com.

$S. 78^{\circ} 35'.$

Note ; The Sine of $101^{\circ} 25'$ is found by subtracting it from 180° according to Chapter 1. *Section 2. Proposition 8. Of the Uses of the Tables of Sines, Tangents, &c. in Page 300.*

2. To find the Side BD, the Proportion is,

$S. BDC \dots Side BC :: S. BCD \dots Side BD.$

$S. 101^{\circ} 25' \dots 76 \text{ Yards} :: S. 33^{\circ} 53' \dots Yds. 43.3 \text{ Tenths.}$
 180° com.

$S. 78^{\circ} 35'.$

Problem. VI. Case 2 and 3 *Of Obliquangles.*

Two Sides, and one Angle opposite to one of them given ; to find the other opposite Angle, and the Third Side.

Note ; The given Angle Obtuse, the Angle sought is Acute.

But when the given Angle is Acute, and opposite to the lesser given Side, then the required Angle is doubtful, whether Acute, or Obtuse, and ought to be determined before the Operation.

Examp. In the Oblique Triangle BCD, *Plate 2. Fig. 6.*

Side

Side $\left\{ \begin{array}{l} BC \ 106 \\ DB \ 65 \end{array} \right\}$ Yards } given : $\left\{ \begin{array}{l} \text{Angle } BDC \text{ Obtuse,} \\ \text{and the} \\ \text{Side } CD \end{array} \right\}$ req.

Angle BCD 31d. 49m. } This Triangle is made by *Prob. 15. of Geometry*, in *Page 19.*

1. For the Angle *BDC* the Proportion is,

As the Side *BD*, is to the Sine of the Angle *BCD*; so is the Side *BC*, to the Sine of the Angle *BDC* required. Or thus,
Side *BD* .. S *BCD* :: Side *BC* .. S. *BDC*.

63 Yards .. S. 31d. 49m. :: 106 Yards .. S. 59d. 17m. which
Subtract from ————— 180d. 00m,

Remainder is the Angle *BDC* ————— 120d. 43m.

Note; The Proportion produceth 59d. 17m. for the required Angle: But being Obtuse, you must take it's Supplement to 180d. viz. 120d. 43m. as above is done.

2. Find the third Angle by the 9th of Section 1. of this Chapter, in *Page 35.* then you may find the Side *CD* by the First Case.

This Case hath been omitted by most, the Reason (I suppose) is the doubtfulness of the required Angle; but if determined (before) to be either Acute or Obtuse, the third Side is limited, and then may be a Case as well as any other; And the Proportions may be,

S. *BCD* .. Side *BD* :: S. *CBD* .. Side *CD*.

S. 31d. 49m. .. 65 Yards :: S. 27d. 28m. .. Yds. 56.8. Or,

S. *BDC* .. Side *BC* :: S. *CBD* .. Side *CD*.

S. 120d. 43m. .. 106 Yds. :: S. 27d. 28m. .. Yds. 56.8 Tenths, as before.

Axiom 3. IN all Plain Triangles; as the Sum of two Sides, is to their Difference; so is the Tangent of the Half-Sum of their two opposite Angles, to the Tangent of the half Difference of the two unknown Angles. Then,

Add the half Difference of the Angles to their half Sum, finds the greater Angle; and subtract the half Difference from the half Sum, finds the lesser Angle.

Prob. VII. Case 4. and 5. Two Sides, and their contained Angle given; to find either of the other Angles, and the third Side.

Examp. In the Oblique Triangle *BCD*. *Plate 2. Fig. 7.*

Side $\left\{ \begin{array}{l} BC \ 109 \\ BD \ 76 \end{array} \right\}$ Leag. } given : $\left\{ \begin{array}{l} \text{Angle } \left\{ \begin{array}{l} BDC \text{ or} \\ BCD \text{ and} \end{array} \right\} \text{ req.} \\ \text{Side } CD \end{array} \right\}$

Angle CBD 101d. 30m.

This Triangle is made by *Prob. 16. of Geometry*, in *Page 19.*

1. For

1. For the Angles BDC, and BCD, the Operation is,
 Side $\left\{ \begin{array}{l} BC \ 109 \\ BD \ 76 \end{array} \right\}$ The three Angles ——— 180d. 00m.
 Subtract the given Angle CBD — 101d. 30m.
 Sum of Sides 185 The 2 opposite Angles $\left\{ \begin{array}{l} \text{Sum is } 78d. \ 30m. \\ \frac{1}{2} \text{ Sum is } 39d. \ 15m. \end{array} \right\}$
 Their Diff. 33
 Then, As the Sum of the Sides BC and BD, is to their Difference; so is the Tangent of half the Sum of the Angles BDC and BCD, to the Tangent of half their Difference. Or thus,
 Sum BC & BD : Diff. BC & BD :: T. $\frac{1}{2}$ Sum Angles .. 1. $\frac{1}{2}$ Diff.
 185 Leagues .. 33 Leagues :: T. 39d. 15m. .. T. 8d. 17m.
 The half Diff. of the Angles — 8d. 17m.

Added, is the greater Angle — 47d. 32m. BDC
 Subtracted, is the lesser Angle — 30d. 58m. BCD } req.

2. The Proportion for the Side CD, (by the First Case of Oblique Triangles) may be this :

S. BCD .. Side BD :: S. CBD .. Side CD.

S. 30d. 58m. .. 76 Leag. :: S. 101d. 30m. .. Leag. 144.5 tenths.

Axiom 4. From the Half Sum of the three Sides, subtract each Side (but first that Side opposite to the Angle required, then the rest) severally, noting their Remainders. Then, As the Product of the Half Sum of the Sides, and First Remainder, is to the Product of the other Two Remainders; so is the Square of Radius to the Square of the Tangent of half the Angle opposite to that First Remainder.

Prob. 8 Case 6. Three Sides given; to find an Angle.

Example. In the Triangle BCD. Plate 2. Fig. 8.

The Side $\left\{ \begin{array}{l} BC \ 105 \\ BD \ 85 \\ CD \ 50 \end{array} \right\}$ Feet given : Angle $\left\{ \begin{array}{l} BDC \\ BCD \\ CBD \end{array} \right\}$ req.

This Triangle is made by Prob. 17. of Geometry, in P. 19 & 20.

The Operation for the Angle CBD is feet

BC	105	The half Sum	120. co. ar.	7.920819
Side BD	85	The First Remainder	70. co. ar.	8.154902
CD	50	The other 2 Remain.	35 Logar.	1.544068
Sum of Sides	240		15 Logar.	1.176091
$\frac{1}{2}$ their Sum	120		Sum	18 705880
From $\frac{1}{2}$ Sum	70	Tangent	14d. 02m.	$\frac{1}{2}$ Sum 9.397940
Sub. each side	35	Double	14d. 02m.	
there remains	15	Produce it	28d. 04m.	the Angle CBD.

This *Axiom* finds an Angle at one Operation, yet not being applicable to the instrumental way of working Proportions, you have this fourth *Axiom* in other Terms; which finds an Angle at two Proportions, and may be wrought both Instrumental and Logarithmic.

Axiom 4. Useful, when three Sides of a Triangle are given; to find an Angle.

As the longest Side, is to the Sum of the two shortest; so is the Difference of the two shortest, to the Difference of the Segments of the Base or longest Side.

Note; Let fall a *Perpendicular* (from the Angle opposite) to the Longest Side, which divideth it into two Segments; and the Oblique Triangle into two Right-Angled-Triangles.

As in the aforefaid Triangle BCD Plate 2. Fig. 8.

Let fall the *Perpendicular* DA, which makes the Segments of the Base to be BA, and AC, and the two Right-Angle-Triangles BAD, and CAD, and the Difference of the Segments BE.

1. To find BC the Difference of the Segments of the Base.

Shortest Sides ————— { BD ————— 85 Feet.
CD ————— 50 Feet.

Added, is the Sum of the two shortest Sides ————— 135 Feet

Subtracted is their Difference ————— 35 Feet.

Then, as the Side BC, is to the Sum of BD and CD; so is the Difference of BD and CD, to BE the Difference of the Segment BA and AC. Or thus.

Side BC .. Sum BD & CD :: Diff BD & CD .. BE the Diff. of Seg.
105 Feet .. 135 :: 35 Feet .. 45 Feet.

The Side BC 105 Feet.

Diff. Segments BE 45

Feet

Added is ————— 150 { the half is { 75 BA the greater } Seg-
Subtracted is ————— 60 { 30 AC the lesser } ment.

2. The Angles BCD or CBD, may be found by the 4th Case of Right-angle Triangles, in Page 39. Thus,

Hypot. BD .. Radius :: Leg. AB .. S.ADB.

85 Feet .. S. 90d. :: 75 Feet .. S. 61d. 56m.

Which subtracted from ————— 90d. 00m.

Remainder is the Angle CBD ————— 28d. 04m. as before.

Thus much for Plain Triangles; and to compleat Trigonometry, Spheric should be next. But I count the Application of this before the Doctrines of that, most conducive to the

the *Learners, Proficiency*: Therefore will descend to the necessary Uses of Plain Trigonometry in Plain and Mercator's Sailing, which will make way for Spheric Trigonometry.

CHAP. III. *Plain Trigonometry applied in Problems of Sailing by the Plain Sea-Chart, commonly called Plain-Sailing.*

AND that nothing may be wanting to the Accomplishment of Navigation, I will begin with the *Julian Kalendar*, and then the Use of the Plain-Chart, before I apply Plain Trigonometry to Plain-Sailing.

Section I. The common Notes of the Julian Kalendar; to find the Prime, Epact, Dominical Letter, Easter Day, the Moon's Age, Southing, and time of High-water.

Problem I. To find the Golden Number, Cycle of the Sun, and Roman Indiction.

Definitions. 1. **T**HE Golden Number or Prime, is a Circular Revolution of 19 Years; in which Space of time (it has been supposed) the Sun and Moon finish all their Variety of Aspects.

2. The Cycle, or Circle of the Sun, maketh its Revolution in 28 Years; in which time all the Variety of Dominical Letters, and Leap-Years expire, and the 29th Year the Circle begins again; which Number serves to find the Dominical Letter for any Year, past, present, or to come.

3. *Roman Indiction* consisteth of 15 Years; for once in 15 Years the subdu'd Nations were to pay Tribute to the Romans; a thing now out of Use with us.

The Rule out of Mr. Street's Memorial Verses on the Ecclesiastic and Civil Calendar.

When 1, 9, 3, to th' Year hath added been;
Divide by 19, 28, 15.

Examp. I would know the Golden Number, Cycle of the Sun, and Roman Indiction for the Year 1740.

The Operation.

The Year 1740	1740	1740
Add 1	9	3
Sum is 1741	1749	1743
19) 1741 (91	28) 1749 (62	15) 1743 (116
31	69	24
(12)	(13)	93
		3

For the Year 1740 { Golden Number } is { 12
 { Cycle of the Sun } { 13
 { Roman Indiction } { 3

Problem II. To find the Epact for any Year.

Definition. The Epact is 11 Days the Year of the Moon lacketh of the Sun's Year: The Lunar being 354 Days, and the Solar-Year, 355 Days.

Note; The Epact never exceedeth 29, and alters every Year 11, and is used to find the Moon's Age, and Easter-Day.

Also, **Note,** The Prime changeth the First of January, but the Epact the First of March. The Rule is.

1. Find the Golden Number, by Prob. 1.
2. Divide the Golden Number by 3, and note the Remainder.
3. Multiply the Remainder by 10, and note the Product.
4. To that Product add the Golden Number; the Sum (if it exceeds not 30) is the Epact; but if it doth, subtract 30 therefrom, and the Remainder is the Epact?

Example. For the Year 1740: I demand the Epact;

To the Year 1740 add 1, and the Sum is 1741, which divide by 19, and the Quotient is 91, and the Remainder is 12; so that the Golden Number is 12, which divide by 3, the Quotient is 4.

And the Remainder is 0; So that the Epact will be the same as the Golden Number, viz. 12, for the Year 1740.

Problem III. *To know if it be Bissextile or Leap-Year.*

Definition. Leap-Year is every Fourth Year, and so called from its leaping a Day more that Year, than in a common Year; for in the common Year, any fix'd day of a Month changeth successively the Day of the Week; but in the Leap-Year, it skips, or leaps over one Day.

Note. The Common Year hath 365 Days in it, but Leap-Year 366, and then *February* hath 29 Days, which in Common Years hath but 28 Days.

The Rule. Divide the Year by 4, what's left shall be,
For Leap-Year 0, for past 1, 2, or 3.

Example. The Year 1740; what is it, a Common Year, or Leap-Year.

4)1740(435 Quotient, and Remainder is 0; so that the
 0 Year 1740 is Leap-Year.

Problem IV. *To find the Dominical Letter for any Year.*

Definition 1. The Week Days in Kalenders, or Almanacks are expressed by the first seven Letters of the Alphabet, and one of them is a Dominical Letter.

2. *Dominical Letter, or Lord's-Day Letter,* is that which stands for it, commonly called *Sunday*.

The Rule. Divide the Year, it's 4th, and 4, by 7;

What's left, subtract from 7; the Letter's given.

Note 1. When it's Leap-Year, there are two Dominical Letters; one serves to the 25th of *February*, the other from thence to the Year's-end.

2. The Dominical Letter goeth backward in a Common Year one Letter, but in Leap-Year two Letters.

3. The Leap-Year having two Dominical Letters, it's the latter of them that this Rule finds.

Examp. For the Year 1740: I demand the Dominical Letter.

The Operation.

The given Year (by *Problem 3.*) is a Leap-Year ——— 1740
It's fourth part is ——— 435
To it add ——— 4
The Sum is ——— 2179
Sect. I.

7)2179(311 Quotient, and Remainder is 2; which
 (2 subtract from 7, rests 5 for the Dominical
 Letter; that is, E; but the Year 1740
 being Leap-Year hath two Dominical Letters, which are FE.

Problem. V. By the 19 Epacts; to find Easter-Limit, from the beginning of March inclusive.

Definitions 1. Easter-Limit, is the 14th Day of the Paschal New-Moon (or the New-Moon nearest the Vernal-Equinox) after the First of *Mar. h.*

2. The Vernal Equinox, is supposed to be fixed to the 21st of *March.*

3. *Easter-Day*, is the Sunday after the 14th Day of the Paschal New-Moon; and is never before the 22d Day of *March*, nor after the 25th Day of *April.*

The Rule.

1. Find the Epact by *Problem 2.*

2. The Epacts take from 47; but two:

The greatest take from 77; 'twill do.

Example. I demand Easter-Limit for the Year 1740.

The Operation.

The Epact for the Year 1740 (by *Problem 2.*) is — 12
 Which subtract from ————— 47

Remainder is Easter-Limit from the 1st of *March* 35 Days,
 that is, the 4th Day of *April* for the Year 1740.

Problem VI. To find Easter-Day for any Year.

Definition. Easter-Day, is next Sunday after Easter-Limit, or the 14th Day of the Paschal New-Moon.

Note; Easter-Day is not less than 22 Days, nor more than 56 Days from the First of *March.*

The Rule.

1. Find the *Dominical Letter* by *Problem 4.*

2. And Easter-Limit by the last Problem.

3. The Letter more by 4, from Limit take;

What's left from nearest 7's, shall *Easter* make.

D 2

Example.

Example. For the Year 1740, I demand *Easter-Day*?

The Operation.

Dominical Letter (by *Prob. 4.*) is FE, or _____ 5
To it add _____ 4

The Sum is _____ 09

Which subtraçt from *Easter Limit* (found by *Prob. 5.*) _____ 35

Remainder is _____ 26

Which subtraçt from nearest 7s, _____ 28

Remainder is _____ 2

Which added to *Easter Limit* 35, Sum is *Easter-Day*, 37 Days from the First of *March*, which makes the 6th Day of *April*, for the Year 1740.

Problem VII. To find the Moon's Age.

Definition. The Moon's Age is, how many Days are past since the Day of her Change, which Age never exceeds 30 Days.

The Rule, 1. Find the Epact by *Problem the 2d.*

2. To the Epact add the Day of the Month, and the Number of the Month; the Sum if it exceeds not 30, is her Age; but if it doth, subtraçt 30 as oft as you can, and the Remainder is her Age.

Note, The Numbers of the Months are these,

January, February, March, April, May, June,

0, 2, 1, 2, 3, 4,

July, August, September, October, November, December.

5, 6, 8, 8, 10, 10,

Examp. The 21st of *May* 1740. I demand the Moon's Age?

The Operation.

The Epact (by *Prob. 2.*) for the Year 1740 is _____ 12

To it add the Day of the Month _____ 21

And the Month *May's* Number is _____ 3

The Sum is _____ 36 Days

Which being more than 30 by _____ 6 Days
is the Moon's Age required.

Problem VIII. To find the Moon's Southing.

Definition. The Moon's Southing, is the time of her coming to, or upon the *Meridian*; which from the *New Moon* to her *Full*, is after Noon, but from the *Full* to the *Change*, is before Noon.

The

The Rule. 1. Find the Moon's Age by the last Problem.

2. Multiply her Age by 4, and divide the Product by 5; the Quotient is Hours, and the Remainder is so many times 12 Minutes of an Hour, and both is her Southing.

Example. The 21st of May, 1740; I demand the Moon's Southing?

The Operation.

The Moon's Age (by Prob. 7.) is _____ 6 Days
Multiply by _____ 4

The Product is _____ 24

That divided by 5, the Quotient is 4 Hours, and the Remainder is 4 which makes 48 Minutes; so that the Moon's Southing is 4 Hours 48 Minutes, Afternoon, that is, 48 Minutes after 4 in the Afternoon, the Moon cometh to the Meridian.

Prob. IX. To find the time of full Sea, or high Water at any place.

The Rule 1. Find the Moon's Southing by the last Problem.

2. To the Southing, add the Point of the Compass making Full Sea, (on the Full and Change Day) for the Place proposed; that Sum is the Time of Full Sea, or High-water.

Note; The Point of the Compass making Full Sea on the Full and Change Day, may be found (in the *Tide-Table*) in the *Mariner's-Kalendar*.

Examp. The 21st of May 1740; I demand the time of High-water at London?

The Operation. The Moon's Southing (by Prob. 8.) for the 21st of May, 1740, is _____ 4h. 48m. Afternoon.
To it add London SW. and NE. _____ 3h. oom.

The Sum is time of High-water _____ 7h. 48m. Afternoon.

Sect. II. *The Use of the Plain-Chart, or Plot.*

IT's requisite to understand the Plain-Chart before the Cases of Plain-Sailing; For it conduces much to the understanding thereof: And for the better understanding of it, mind these following

Definitions. 1. The Plain-Chart supposeth the Earth and Sea to make one Flat Superficies, or Long-square; in which the Meridians are Parallel, and the Degrees of Latitude and Longitude

gitude, equal in all Places; which is only true in the Equator.

2. The Equator, is a Line drawn East and West, and is 90 degrees distant from each Pole: From it Latitude beginneth, and in it Longitude is counted.

3. The Poles are two opposite Points, one called the North Pole; the other the South Pole; and lie North and South from each other; at them is the greatest Latitude 90 Degrees.

4. The Meridians, are Lines (in this Chart) parallel to each other, and perpendicular to the Equator; and lie North and South; on which are counted the Degrees of Latitude.

5. Parallels of Latitude, are Lines parallel to the Equator, and lie East and West.

6. Latitude, is the Breadth, or Distance of any Parallel of Latitude from the Equator; from whence it's counted both ways to each Pole, ending in 90 Degrees, the greatest Latitude.

7. North Latitude, is on that side of the Equator towards the North Pole; and South Latitude towards the South Pole.

8. Difference of Latitude, is the Breadth, or nearest Distance of any two Parallels of Latitude; and sheweth how far one Place lies to the Northward, or Southward of the other; it never exceedeth 180 Degrees.

9. Longitude (in the Plain-Chart) is reckon'd on any Parallel of Latitude, and encrease to the Eastward, till it end in 360 Degrees, the greatest Longitude.

10. Difference of Longitude, Meridian-Distance, and Departure from the Meridian, signify (in the Plain-Chart) one and the same thing, and is the nearest Distance of any two Meridians; it sheweth how far one Place is to the Eastward, or Westward of another.

The Use of the Plain-Chart.

Prob. 1. *To find the Latitude of any Place in the Chart.*

Rule 1. Take the nearest Distance of the Place to any Parallel, or East and West Line.

2. Lay that Distance on the graduated Meridian, setting one Foot of the Compasses in the said Parallel, and turning the other Foot the same way, the proposed Place lieth from it; the last Foot sheweth the Latitude required.

Example.

Examp. What Latitude doth the *Lizard* in *England* lie in?

1. Take the nearest Distance from the *Lizard* to any Parallel, or East and West Line.

2. Lay that Distance (on the graduated Meridian) from the said Parallel, and the moveable Foot sheweth 50 Degrees, the Latitude of the *Lizard*; and it is North Latitude, because Northward of the Equator: Do so for any other Place.

Prob. 2. To find the Course, or Bearing of one Place from another.

The Rule is,

1. Lay a Ruler on the two Places given; and take the nearest Distance from the Center of any Compass to the Ruler's Edge.

2. Slide the Compasses, (being at that Distance) with one Foot close to the Ruler, and the other Foot perpendicular to it; in so doing the perpendicular Foot points out (among the Rumb-lines) the Course, or Bearing of the proposed Places, from one another.

Example. I demand the Course from the *Lizard* in *England*, to the Island of *Barbadoes*.

1. Laying a Ruler's Edge on the *Lizard* and *Barbadoes*, take the nearest Distance from the Center of a Compass to the edge of the Ruler.

2. Slide the Compasses along by the Ruler, keeping one Foot Perpendicular to it, and it sheweth (among the Rumbs) the Course to be SW. $\frac{1}{2}$ W. nearest, from the *Lizard* to the Island of *Barbadoes*, the opposite Point (viz.) NE. $\frac{1}{2}$ E. is the Course from the Island *Barbadoes* to the *Lizard*.

Problem 3. To find the Distance of one Place from another.

The Rule. Extend the Compasses from one Place to another.

Measure that Distance on a Scale of Leagues, or on the Graduated Meridian; the first sheweth the Distance in Leagues, the latter in Degrees. This is so easy, it needs no Example.

Problem 4. To find the Departure, or Meridional Distance between any two Places the Chart.

1. *The Rule.* Take the nearest Distance from one of the given Places, to any Meridian.

2. The

2. The Compasses being kept at that Distance, move them Perpendicular along that Meridian, till you bring both Feet of the Compasses into the Parallel of the other Place, there stay the Compasses.

3. The Distance from the Perpendicular Foot, to the other proposed Place, being measured on the Graduated Meridian, or on the *Scale of Leagues*, giveth the *Meridional Distance* required.

Example. I demand the Meridional Distance between the *Lizard* and *Cape Finisterre*?

1. Take the nearest Distance from the *Lizard* to a Meridian, and slide the Compasses with one Foot on it, and the other Perpendicular, till both Feet come to the Parallel of *Cape Finisterre*.

2. Then the Distance from the Perpendicular Foot, to *Cape Finisterre*, being measured on the Meridian, is 3 Degrees 18 Minutes, or 66 Leagues, which is the Meridional Distance, and sheweth *Cape Finisterre* is 66 Leagues to the Westward of the Meridian of the *Lizard*, and consequently the *Lizard* lies 66 Leagues to the Eastward of the Meridian of *Cape Finisterre*.

Problem 5. *The Latitude a Ship is in, and her Meridional Distance given; to find in the Chart where the Ship is.*

The Rule. 1. Lay off the Meridional Distance (according to its Nature, whether to the Eastward or Westward) from the Place it's counted from; and then the nearest Distance from that, to any Meridian, must be kept in one pair of Compasses.

2. With another pair of Compasses, take the nearest Distance of the Latitude, from any Parallel, or East and West Line.

3. Then move both pair of Compasses Perpendicular, one on the Meridian, the other on the Parallel, 'till both Perpendicular-Foot meet, and there is the Place in the Chart representing the Place the Ship is in.

Sect. III. Plain Trigonometry applied in Plain-Sailing.

Definition. 1. **N**avigation, is the guiding or directing a Ship (thro' the Ocean) from one Place to another; it's divided into two Generals; Domestic and Remote.

2. *Domestic*, or Home Navigation, is Coasting or Sailing along shore; in which the *Mariner's Compass*, and *Lead*, are the chief Instruments.

3. *Remote*.

3. *Remote*, (which more properly bears the Name of Navigation) is the conducting a Ship to any Port, and the finding what Latitude and Longitude she is in, at any time; in the Practice of which, the Mariners have these helps, the Compass, the Log, and the Latitude.

4. The Compass, is a Circle divided into 4 Quadrants, Quarters, or principal Points; East, West, North, and South; each Quarter into 8 equal Parts, being in all 32 Rumbs, or Points, as in *Figure 16. of Plate 2.* So that steering by the Compass (well made, and duly rectified) is known how, or which way the Ship sails to a small matter.

5. The Log-line, (truly marked, or some other good way) is the Instrument whereby the Mariners measure the Ship's Distance sailed, in Minutes, Miles, or Leagues, every Hour, Watch, or Day.

Note, Each Knot in the Log line ought to be 50 Feet from each other, and not 42 Feet, or 7 Fathom; an Error too frequent among the English Navigators, and long since refuted by Mr. *Norwood* in his *Seaman's Practice*.

Also the $\frac{1}{2}$ Minute Glass, used with the Long-line, ought to be truly 30 Seconds of Time, and not 25 or 26 Seconds, as chiefly made now, which are so called.

6. The Third Help, is the Knowledge of the Latitude from whence he sails, to which he is bound, and where the Ship is at any Time; this attained by Coelestial Observation (at Sea with a Quadrant or Forestaff) taking the Sun, or Star's Meridional Altitude.

Now, any two of these three Things exactly known, the Navigator comes to know at any time, where he is, how far he hath run, and how far he is yet to run, which way, or upon what Point of the Compass he is to steer; and all this by Trigonometry, in the three Kinds, *viz.*

Plain-Sailing, *Wright's-Sailing*, and *Circle-Sailing*; as shall be shewed in order: And first of Plain-Sailing, in which take these Five General Rules following.

Rule 1. That 20 Leagues being equal to 60 Miles, or Minutes, is also equal to one Degree of Latitude.

But *Note*, One of these Miles or Minutes containeth 6000 Feet, and is greater than a Statute or common Mile, which is but 5000 Feet; of which about 69 $\frac{1}{4}$ Miles make a Degree; whereas in the Practice of Navigation, 60 are counted to a Degree on the Meridian, or any great Circle.

2. *General Rule.* To find the Difference of Latitude, when the Latitudes of two Places are given.

The La- { both { North { or both { South { subtract } finds
titudes { one { the other { add } the difference of Latitude.

3. *General Rule.* To find the Latitude the Ship is in, when the Latitude sailed from, and the difference of Latitude is given; for these are the two following Cases.

Case I.

In { North } Latitude sailing to the { North } ward, the
South } Latitude increased, add.

Case II.

In { North } Latitude sailing to the { South } ward, the
South } Latitude decreaseth, subtract.

And here *Note*, When the Latitude decreaseth, and the Difference of Latitude is greater than the Latitude sailed from, the Ship hath crossed the Equator, and changed her Latitude; either from North into South, or South into North.

4. *General Rule* The Sum of the three Angles of every Plain Triangle, is equal to 16 Points of the Compass: For,

1 Point }
8 } Points { of the Compass is equal to { 11d. 15m.
16 } { 90 } Degrees.
32 } { 180 }
 { 360 }

5. *General Rule.* If a Ship sails East or West, she keeps in the same Latitude; and if a Ship sails North or South, she keeps in the same Longitude.

Note, Plain Sailing is divided into three Parts, viz.

1. In a Right Angle-Triangle, relating to a single Course, in which are Six Cases.

2. In a Right-Angle-Triangle, relating to several Courses, called a Traverse.

3. In an Oblique Triangle, in which are but four Cases, tho' multitude of various Questions.

The First Part of Plain Sailing is contained in the six Problems, or Cases following.

Prob.

Sect. III. *Plain Sailing, the first Part.*

39

Prob. or Case 1. *Course, and Distance sailed given; to find the Difference of Latitude, and the Departure from the Meridian.*

Example. Admit a Ship runs 496 Minutes SW. by W. from the *Lizard* in 50d. 00m. North Latitude: I demand the Latitude she is in, and how far she is departed from the Meridian?

Observe, That in all Problems of Navigation, make the upper end of the Book, or Slate, to be the North; then the Right-hand is the East, the Left-hand the West, and the lower End is the South. Then,

To delineate this Problem by the Plain-Scale.

1. Draw the Meridian AB (*Plate 2. Fig. 9.*) towards the Right-hand, when the Course is Westerly, but when Easterly towards the Left hand; and put A at the upper End when the Course is Southerly, but at the lower End when it's Northerly.

2. With a Chord of 60 Degrees, and one Foot on A, describe an Arch; on that Arch lay 5 Rumbs (because SW by W. is 5 Points from the South) taken from the Scale of Rumbs, and by it draw a Line AC.

3. From any Scale of equal Parts, take the Distance run 496 Minutes, and lay it from A to C; then A represents the Place sailed from, C the Place the Ship is come to.

4. From C let fall the Perpendicular CB, to cut the Meridian in B, and it's done. Then, measure AB, and BC, on the same Scale of equal Parts, that AC was taken from, will shew how much the Difference of Latitude, and Departure from the Meridian is, by the Plain-Scale.

These Directions with the following Explanation being well considered, will shew how to delineate, and answer any of the Six Cases of Plain-Sailing by the Plain Scale: Therefore I omit the Delineations in the five following Cases; having given sufficient Directions to make any Rectangle Plain-Triangle in Problems 10, 11, 12, and 13 of Practical Geometry, and such are all the Cases in this Part of Plain-Sailing.

This

This Right-Angle Triangle ABC, (*Plate 2. Fig. 9.*) may be made by *Prob. 10. of Geometry*; in which *Note*;

1. The Hypotenuse AC represents (the Point of the Compass the Ship hath steered, and) the Ship's Distance run.
2. The Leg AB, (the Meridian, that is, the North or South Point of the Compass) the Difference of Latitude.
3. The Leg BC, (the East or West Point of the Compass, and a Parallel of Latitude) the Departure from the Meridian.
4. The Angle BAC, (the Angle of the Ship's Course).
5. The Angle ACB, (the Angle of the Complement of the Ship's Course).

Note, The Angle that the Point of the Compass (steered by, or upon) maketh with the Meridian, or North, and South Point of the Compass, is called the Angle of the Ship's Course, and the Angle it maketh with the East, or West Point, is the Complement of the Course.

The Course, in this Example being SW. by W. is 5 Points from the South, or Meridian, and makes 56d. 15m. The Complement of the Course is 3 Points; that is, 33d. 45m. as may be seen in the Table, Intituled, A Table of the Angles which every Rumb (or Point of the Compass) maketh with the Meridian. At the end of this Book.

The Things thus explained, the Proportion (by *Chapter 2. Section 2. Axiom 1. and Case 1. of Plain Right-Angle Triangles in Pages 36 and 37.*) is as follows.

For the Difference of Latitude, these three Proportions, viz.

$$\begin{array}{l} \text{Radius} \\ \text{Sec. Course} \\ \text{Sec. c. Course} \end{array} \left. \vphantom{\begin{array}{l} \text{Radius} \\ \text{Sec. Course} \\ \text{Sec. c. Course} \end{array}} \right\} \text{.. Distance} :: \left. \vphantom{\begin{array}{l} \text{S. c. Course} \\ \text{Radius} \\ \text{T. c. Course} \end{array}} \right\} \text{.. Diff. Lat.}$$

All these three Proportions may be wrought by the Logarithms, but I only work the first.

By Gunter's Scale.

Radius .. Distance :: S. c. Course .. Difference of Latitude.
 S. 8 Points .. 496 Min. :: S. 3 Points .. Min. 275.6 Tenth
 Latitude sailed from, is _____ 50d. 00m. North.
 The Diff. of Latitude, Min. 275.6 or 04d. 36m.

Subtract, giveth Latitude the Ship is in, 45d. 24m. North.

For

For the Departure, these three Proportions, viz.

Radius } .. Distance :: { S. Course }
 Sec. Course } .. Departure. { T. Course }
 Sec. c. Course } .. Radius { }

The first of these by Gunter's Scale,

Radius .. Distance :: S. Course .. Depart. from the Merid.
 S. 8 Points .. 496 Min. :: S. 5 Points .. Minutes 412.4 Tenths.
 So that the Departure from the Meridian is Minutes 412.4 Tenths, which makes 6d. 52m. Meridian-Distance West.

Prob. or Case 2. Course and Difference of Latitude given, to find the Distance run, and the Departure from the Meridian.

Examp. If a Ship runneth SE by E. from 1d. 45m. North Latitude, and then (by Observation) is in 2d. 50m. South Latitude. What is her Distance and Departure? *Plate 2. Fig. 10.*

This Triangle ABC may be made by *Prob. 12. of Geometry.* In this *Example*, having Latitude the Ship sailed from, and Latitude she is in by Observation, there are the Latitudes of two Places given; and by the Second General Rule, in *Page 58.* the Difference of Latitude is found, as followeth;

Latitude sailed from ————— 1d. 45m. North
 Latitude by Observation, is ————— 2d. 50m. South.

The Difference of Latitude, is ————— 4d. 35m. or 275 Minutes; found by multiplying by 60, the Minutes in a Degree.

1st, For the Distance the Proportion may be this;

S. c. Course .. Diff. Lat. :: Radius .. Distance.
 S. 3 Points .. 275 Min :: S. 8 Points .. 495 Minutes.

2d, For the Departure, this;

S. c. Course .. Diff. Lat. :: S. Course .. Departure.
 S. 3 Points .. 275 Min. :: S. 5 Points .. 412 Minutes : Or 6d. 52m. Easting; that is, the Ship is so much to the Eastward of the Meridian of the Place she sailed from.

Problem, or Case 3. Course, and Departure from the Meridian given; to find the Distance, and Difference of Latitude.

Examp. If a Ship sails NE by E. from a Port in 3d. 15m. South Latitude, until she depart her first Meridian 412 Min. demand her Distance, and what Latitude she is in? *Plate 2. Fig. 21.* This Triangle may be made by *Prob. 12. of Geometry.*

1st, For the Distance, the Proportion is this.

S. Course .. Departure :: Radius .. Distance.

S. 5 Points .. 412 Min :: S. 8 Points .. Min. 495.5 Tenths.

2^d, For the Difference of Latitude, this;

S. Course .. Departure :: S. c. Course .. Diff. Latitude.

S. 5 Points .. 412 Min. :: S. 3 Points .. 275 Minutes, which being reduced, is 4 Degrees 35 Minutes Northing, by which find the Latitude the Ship is in, as here-under.

Latitude failed from, is ————— 3d. 15m. South.

Difference of Latitude, is 275 Min. or — 4d. 35m. North,

Subtract, giveth Latitude the Ship is in 1d. 20m. North, having cross'd the Equator.

Problem, or Case 4. Distance, and Difference of Latitude given; to find the Course, and Departure.

Example. Suppose a Ship sails 496 Min. between the South and the West, from a Port in 2d. 48m. South Latitude; and then by Observation is in 7d. 23m. South Latitude: What Course hath she steered, and what Departure hath she made? *Plate 2. Fig. 12.* This Triangle may be made by *Prob. 11. of Geometry.*

By the two Latitudes mentioned in this *Example*, find the Difference of Latitude, as followeth,

Latitude failed from, is ————— 2d. 48m. South.

Latitude by Observation, is ————— 7d. 23m. South.

Subtract, gives the Diff. of Latitude 4d. 35m. or 275 M.

1st, For the Course, the Proportion is.

Distance .. Radius :: Diff. Lat. .. S. c. Course.

496 Min. .. S. 90d. :: 275 Min .. S. 33d. 40m.

Which subtract from 90d. the Remainder 56d. 20m. is the Course, which makes 5 Points nearest; or SW by W. for the Ship's Course.

2^d, The Proportion for the Departure, is,

Radius .. Distance :: S. Course .. Departure.

S. 90d. .. 496 Min. :: S. 56d. 20m. .. 412 Minutes.

Problem, or Case 5. Distance and Departure given; to find the Course, and Difference of Latitude.

Examp. Admit a Ship sails 496 Minutes between the North and the West, from the Island *Bermudas*, in Latitude 32d. 30m. North, until her Departure is 412 Minutes; what Course hath

hath she Steer'd? And what Latitude is she in? Plate 2. Fig. 13.
This Triangle may be made by Prob. 11. of Geometry.

1st, For the Course take this Proportion.

Distance .. Radius :: Departure .. S. Course.

496 min. .. S. 90d. :: 412 min. .. S. 56d. 10m. N. Westerly.

That is, 5 Points, which makes the Course to be NW. by W.

2d, For the Difference of Latitude.

Radius .. Distance :: S.c. Course .. Difference of Latitude

S. 90d. .. 496 min. :: S. 33d. 50m. .. 275 min. or 4d. 35m.

d. m.

Latitude sailed from ————— 32 : 30 North.

Difference of Latitude 275 Minutes, or ——— 4 : 35

Latitude the Ship is in ————— 37 : 05 North.

Problem, or Case 6. Difference of Latitude, and Departure given;
to find the Course, and Distance.

Example. If a Ship's Southing be 275 Minutes, and her East-
ing 412 Minutes, What is her Course and Distance? Plate 2.
Fig. 14. This Triangle may be made by Prob 13. of Geometry.

1st, For the Course, take this Proportion.

Diff. Lat. .. Departure :: Radius .. T. Course.

275 Min. .. 412 Min. :: T. 45d. .. T. 56d. 17m. South-
Easterly, or 5 Points, which makes the Course to be SE. by
E. nearest.

2d, For the Distance, this Proportion.

S. Course .. Departure :: Radius .. Distance.

S. 56d. 17m. .. 412 Min. :: S. 90d. .. 495 Min.

The six preceding Problems are the common Cases of Plain
Sailing; which the Learner ought to be well acquainted with:
and for that End I here add six more for Practice, whose An-
swers may be found by the foregoing Rules.

Question 1. A Ship in 2d. 10m. South Latitude, sails N. by E.
89 Leagues: What Latitude is she in; and what is her Departure?

Answer. Latitude 2d. 12m. North, and Departure Leagues
17 and 35 parts of a Hundred.

Question 2. A Ship sailing SSW. from a Port in 41d. 30m.
North Latitude; and then by Observation, the Ship is in 36d.
57m. North Latitude: Demand the Distance Run, and Departure?

Answer. Distance Run, 98 Leagues 5 Tenths, Departure
Leagues 37.6 Tenths.

Question 3. A Ship sails SSW. half W. from 2d. 30m. South
Latitude,

Latitude, until the Departure be 59 Leagues: I demand her Distance Run, and the Latitude she is in?

Ans^w. Distance Run 125 Leagues, Latitude 8d. 01m. South.

Quest. 4. If a Ship saileth 360 min. South Westward, from 21d. 59m. South Latitude, until (by Observation) she be in 24d. 49m. South Latitude: What is her Course, and Departure?

Ans^w. Course is SW by W. $\frac{1}{2}$ W. and Departure from the Meridian is 318 Minutes:

Quest. 5. Suppose a Ship saileth 354 min. North Eastward: from 2d. 9m. South Latitude, until her Departure be 150 min. What is her Course, and Latitude she is in?

Ans^w. Course is NNE. $\frac{1}{4}$ East nearest, and Latitude the Ship is in, is 3d. 8m. North.

Quest. 6. Sailing between the North and the West, from a Port in 1d. 59m. South Latitude, and then arriving at another Port in 4d. 08m. North Latitude, which is 209 min. to the Westward of the first Port: I demand the Course, and Distance from the first Port to the second.

Ans^w. Course is NW by N. and Distance of the Ports 371 Minutes, or Leagues $123 \frac{1}{2}$.

So much for the first Part of Plain-Sailing, Traverse is next in order.

Section IV. Plain-Sailing, the second Part; shewing how to resolve a Traverse, or bring several Courses into one.

HAVING learn'd those necessary Problems concerning a single Course, the next in order is a *Compound Course*, commonly called a *Traverse*; in order to the right Understanding thereof, observe the following Definitions:

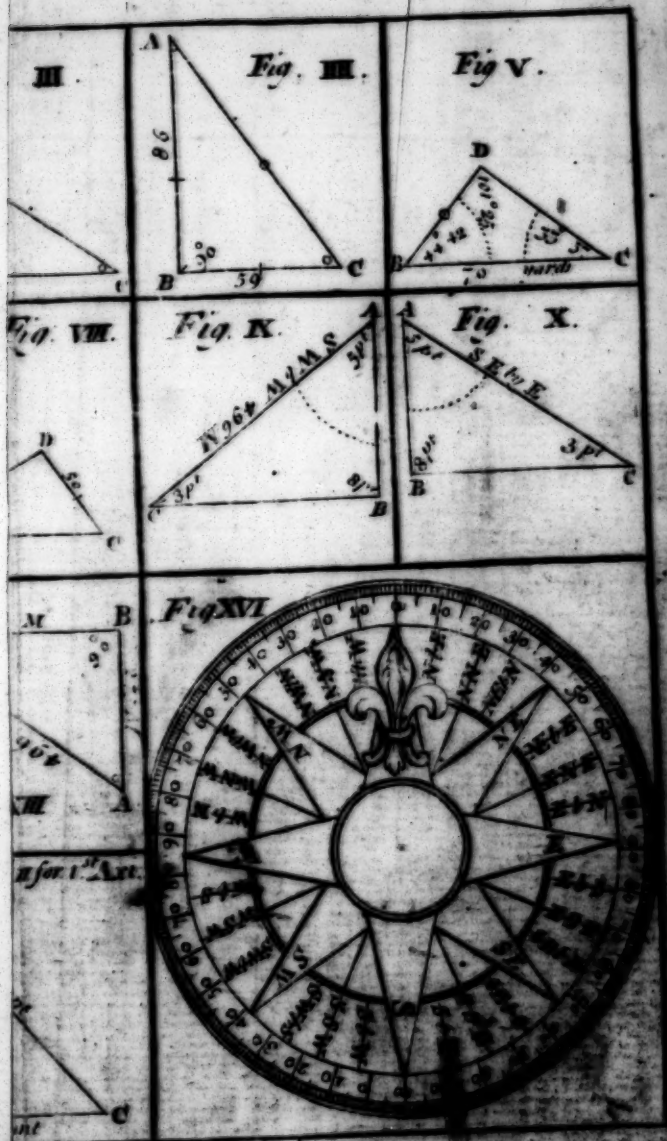
1. A *Traverse*, is when a Ship (meeting with a contrary Wind) saileth on several Courses in 24 Hours.

2. To *resolve a Traverse*, is to reduce or bring several Courses into one; the Courses are known by the Compass, and the Distance by the Log; which in common Voyages is heav'd once in two Hours, but to the *East-Indies* every Hour.

3. The *Log*, is a piece of Wood about seven Inches long, in both Ends of equal Bore, with the Head cut off; and so fastened to a small Chain (the Log-line) at one End, with so much Lead as will sink it when it's put into the Sea, it may be used to find the Distance.

4. The *Log-line*, is a line of equal Spaces, called *Knots*.

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Pla. 2.

Fig. 1.

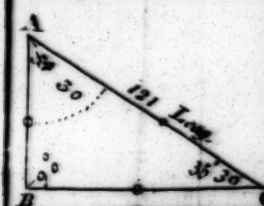


Fig. VI.

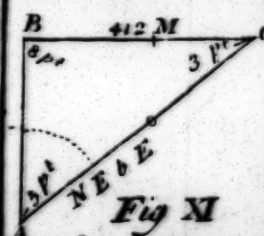
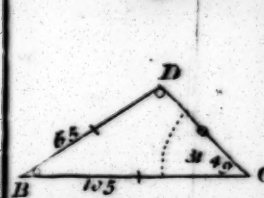
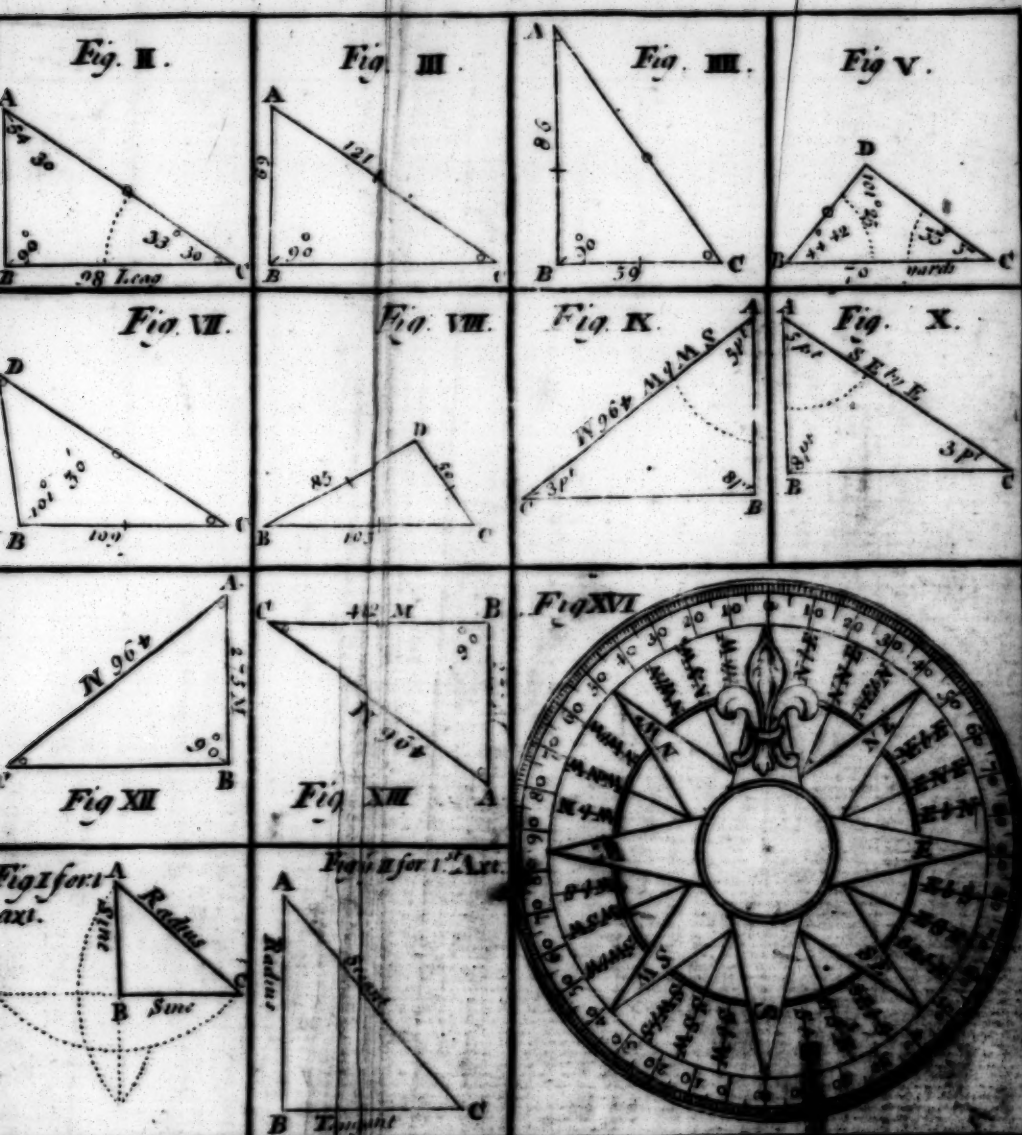


Fig XII



Fig 1 for axi.







by something fastened to it, at every 50 Feet distance for a Knot. Now the *Log-line* being wound on a *Reel*, and the *Log* put into the Sea; if the *Log-line* be veered out so fast as the Ship sails, then look how many Knots are veered out in half a Minute's Time: So many Miles or Minutes doth the Ship run in one Hour.

5. One of these Miles contain 6000 Feet, and is greater than a *Statute* or *common* Mile, that being but 5000 Feet; of which about $69\frac{1}{2}$ (on the Meridian, or any great Circle) is a Degree; but in the Practice of *Navigation*, 60 Miles or Minutes are counted for a Degree, therefore I call them Minutes.

6. In the *Steerage*, or some convenient Place of the Ship, hangeth a *Table* called the *Log-Board*, divided into 5 Columns; wherein are written the *Hours of the Day*, *Courses steered*, *Knots*, &c. veered out; and lastly the *Winds*; as in the Table following.

The Form of the Log-Board.

<i>Hours of the Day,</i>	<i>Courses or Points.</i>	<i>Knots.</i>	<i>Fathoms of 5 Feet.</i>	<i>Winds.</i>
H.	C.	K.	F.	W.
2	SW by S.	7	5	WNW.
4		7	5	W by N.
6	S.	8		WSW.
8		8	5	
10	NW by N $\frac{1}{2}$ W.	4	8	W by S.
12		5	4	
2		5	6	
4	SW.	7		WNW.
6		8		
8	SE.	4	4	SW by S.
10	SW.	4	5	SSE.
12	ESE.	5	3	S.

Note, The Column for Courses is made sometimes just before the Column for the Winds, and then the three narrow Columns stand together.

7. The Day begins and ends at Noon; that is, from Noon to Noon is the Length of the Day.

8. Every Day at Noon the Log-board ought to be copied into a Log-Book, ruled like the Log-board: Then must be cast up how much the Ship hath Sailed on each Course.

9. If the Ship sails by a Wind, it's usual to allow one Point for Leeward way; so that when the Ship is close haled, and lieth 5 Points and a half from the Wind, yet her Course corrected is 6 Points and a half from the Wind.

10. The several Courses (being corrected) and Distances, are to be brought into one Course and Distance; which is called *Resolving a Traverse*, and to lay it down by Scale and Compasses, take the four following Rules, which give the Points that are between each Course, called the Angle between both Courses.

Rule 1. Two Meridians, and two Parallels; the lesser Course subtracted from the greater, gives the Angle between both Courses.

Rule 2. Two Meridians, and one Parallel; add both Courses together.

Rule 3. One Meridian, and two Parallels; subtract the Sum of both Courses from 16 Points.

Rule 4. One Meridian, and one Parallel; add 8 Points, the lesser Course, and the Complement of the greater together; the Sum is the said Angle.

Note 1. North and South are called Meridians, and East and West are called Parallels.

2. By Complement of the greater Course, understand how much it wants of 8 Points.

3. To know the Meridians, and Parallels, the first and second Courses are compared together, and the second and third, and the third and fourth, &c.

Example. A Ship bound to a certain Port, meeting with contrary Winds, sails first S. E. by S. 67 Minutes; then S. E. by E. 53; then W. S. W. 45; then N. E. by N. 74; then West 57; and then S. by E. 83 Minutes: I demand the Difference of Latitude, Departure from the Meridian, and direct Course, and Distance from the first Place departed? Plate 2. Fig. 15.

1. Set down the several Courses and Distances, with the points from the Meridian, &c. as in the following Table.

Number.	Courses	Total in Min.	Points from the Meridian.	Points for Laying down.	Diff. Latitude in Minutes.		Departure in Minutes.	
					North	South	East.	West.
1	E by S	67	3	3		55.7	37.2	
2	E by E.	53	5	14		29.4	44.1	
3	W S W	45	6	5		17.2		41.6
4	NE by N	74	3	3	61.5		41.1	
5	West	57	8	5				57.0
6	S by E	83	1	7		81.4	16.2	
Sum'd up					61.5	183.7	138.6	98.6
Subtract						61.5	98.6	
Difference of Latitude						122.2	40.0	Depart.

2. In the fifth Column put the points for laying down, which are found by the four Rules foregoing: For the first Course always is the same with the Points from the Meridian; For the second Course, it's 14 Points, found by comparing the first and second Courses together, in which is one Meridian and one Parallel; and by the 4th Rule it makes 14 Points for laying down: Again, comparing the second and third Courses, it's one Meridian and two Parallels, which by the Third Rule makes 5 Points for laying down: Again, the third and Fourth Course compared, it's two Meridians and two Parallels; which, by the First Rule makes 3 Points for laying down; and so for the rest, as in the foregoing Table.

3. By these Points for laying down, it's easy to delineate the Traverse; as you see in Plate 2. Fig. 15 which is thus.

First, Draw the Meridian AB, and on A draw an Arch, with the Chord of 60 Degrees, on which Arch lay 3 Points; by it draw a SE by S. Line, laying thereon (from A) 67 Minutes, the Distance run SE by S.

Secondly, With a Chord of 60 Degrees, and one Foot at the end of the SE by S. Line, draw an Arch, on which lay 14 Points: That is, take 7 Rumbs from the Scale of Rumbs, and lay it twice

on the said Arch; by it and the end of the SE by S. Line, draw a SE by E. Line, making it 53 Minutes long, so the second Course is finished.

Thirdly, At the end of the SE by E. Line, in like manner with the Chord of 60 Degrees, draw an Arch, and thereon lay 5 Points, by which and the End of the SE by E. Line draw the WSW. Line, 45 Minutes long.

Fourthly, After the same manner draw the NE by N. Line 74 Minutes long: Then the West Line, 57 Minutes long. And then the S by E. Line, 83 Minutes long, ending in C, the place where the Ship now is.

Lastly, Draw a Line from C to A (the place the Ship departed from) and from C let fall the Perpendicular BC; then is AC the Ship's Distance from the place of Departure, AB her Difference of Latitude, and BC her Departure from her first Meridian, each being measured on the same Scale the other Lines were taken from, will shew how much they are severally, and the Angle BAC measured on the Scale of Chords or Rumbs, shews her Course.

4. Then by Prob. 1. Sect. 3. of this Chap. find the Difference of Latitude, and Departure from the Meridian, for those Courses and Distances severally; that is, by the First Case of *Plain Sailing*, having the Course and Distance run given; to find the Difference of Latitude, and the Departure from the Meridian; and that for each given Course; which place in their proper Columns, thus: If the Course be North Easterly, put the Difference of Latitude in the North Column, under (*North*;) and the Departure in the East Column, under (*East*;) If the Course be South Easterly, then put the Difference of Latitude in the South Column, and the Departure in the East Column; if South Westerly, then in the South and West Columns; and if North Westerly, then in the North and West Columns.

As for Example. The First Course in the foregoing Traverse is SE by S. that is, South Easterly; the Difference of Latitude, Minutes 55.7, place in the South Column; and the Departure, Minutes 37.2 put in the East Column; as in the Table foregoing. The like observe for all the rest.

Note, When the Course is E. W. N. or S. the Distance fall'd then place in the East, West, North or South Columns; as here the Fifth Course is W. the Distance 57 Minutes is placed in the West Column, as you see above in the Table.

5. Having

5. Having found the Difference of Latitude, and Departure from the Meridian for each Course, and placed them in their proper Columns; add up the North, South, East, and West Columns, and subtract the North and South Columns, the one from the other, that is, the least from the greatest, for the Difference of Latitude; in like manner, the East and West Columns for the Departure: As in the foregoing Table, the Sum of the North Column 61.5, subtracted from the Sum of the South Column 183.7, the Remainder 122.2 is the Difference of Latitude Southerly: And the Sum of the West Column 98.6, subtracted from the Sum of the East Column 138.7, the Remainder 40.1, is the Departure from the Meridian Easterly.

6. Then having found the Difference of Latitude, and Departure from the Meridian, the Course and Distance may be found by Problem 6. Section 3. of this Chap. And in this Example, the Difference of Latitude being Minutes 122.2 Southerly, and the Departure Minutes 40.1 Easterly, the Course will be South 18d. 7m. Easterly; that is, S by E. three quarters E. almost, and the Distance Minutes 128 7 which was required.

After this manner may you work any Traverse; and for the Learner's Practice, I subjoin the following Examples.

Examp. 2. Suppose in 24 Hours a Ship saileth as follows, SW by S. 30 Minutes, S. 33. NNW half W. 32. SW. 39. SE. 9. and ESE. 11 Minutes: What is her Difference of Latitude, Departure from the Meridian, direct Course and Distance?

Ans. Difference of Latitude Minutes 67.9 Southerly, Departure Minutes 42.8 westerly, Course is South 32d. 15m. westerly, or SW by S. nearest, Distance Minutes 80.3 Tenths.

Examp. 3. If a Ship saileth (by the Log Board) in 24 Hours as follows, NNE. 83 Min. SW. 74. E by S. 92. NNW. 126. S by W. 47. and NE by N. 78 Minutes: What is her Difference of Latitude, Departure, direct Course, and Distance run?

Ans. Difference of Latitude Minutes 141.7 Northerly, Departure Minutes 55.6 Easterly, Course is North 21d. 25m. Easterly, or NNE. nearest, Distance Minutes 152.3.

Example 4. If a Ship saileth W by S. 87 Min. N. 46. SSE. 75. E. 83. NW by W. 79. NE by E. 57. and NW. by N. 64 Min. I demand her Difference of Latitude, Departure, direct Course, and Distance run?

Ans. The Difference of Latitude Minutes 88.6 Northerly, Departure Minutes 27.5 westerly, Course North 17d. 15m. westerly, or N. by W half W. nearest, Distance 93 Minutes.

Examp. 5. *A Ship saileth as follows, NNE. 55 min. NW. $\frac{1}{2}$ W. 96. S. by E. $\frac{1}{2}$ E. 57. WSW. $\frac{1}{2}$ W. 89. NE by N. $\frac{1}{4}$ E. 100 SW by W. $\frac{1}{2}$ W. 54. and N by E. 50m. What is her Difference of Latitude, Departure, direct Course, and Distance run?*

Ans. Difference of Latitude min. 131.8 Northerly, Departure minutes 92.1 Westerly, Course 34d. 56m. North West-erly, or NW by N. nearest, Distance 161 Minutes.

Examp. 6. *A Ship in 46d. 24m. South Latitude, saileth by the Log board in 24 Hours SE. 8 min. SW by W. $\frac{1}{2}$ W. 6. NE by E. 5. WNW. $\frac{1}{2}$ W. 9. NW. 4. ESE. $\frac{1}{4}$ E 3. S. by E. 7. NNE $\frac{1}{2}$ E. 4. and E. 7 min. What is her Difference of Latitude, Departure, direct Course, Distance run, and Latitude she is in?*

Ans. Difference of Latitude min. 4.62 Southerly, Departure min. 6.17 Easterly, Course is S. 53d. 10m. Easterly, or SE. $\frac{1}{4}$ E. Distance Run min. 7.71, and Latitude 46d. 29m. South.

Examp. 7. *Admit a Ship in 1d. 30m. North Latitude, sails NNE. 6 min. SE by S $\frac{1}{2}$ E. 5. NE by E half E 4. WNW $\frac{1}{2}$ W. 8. SW by S half W. 7. NW by N. 4 ENE. 5. SW 7. and SE by E. 5 min. I demand her Difference of Latitude, Departure, direct Course, Distance run, and what Latitude she is in?*

Ans. Difference of Latitude minutes 2.40 Southerly, Departure min. 1.59 Westerly, Course is South 33d. 31m. West-erly, or SW by S. Distance minutes 2.88, and Latitude she is in 1d. 28m. North.

Thus much for the Second Part of Plain Sailing, called a *Traverse*, we go on to the use of an *Oblique Triangle* in Plain Sailing.

SECT. V. *Plain Sailing the third Part, or the Doctrine of Oblique Plain Triangles applied in Problems of Sailing by the Plain Chart.*

ALtho' this part of Plain Sailing is the least useful, and most difficult; yet for the Learner's Diversion I will add some Problems.

Prob. 1. *Suppose two Ports lie North and South, and a Ship sails from the Northernmost S E. 68 Min. another from the Southernmost sails N E by N. till she meets the first Ship: I demand the Distance of these Ports, and the second Ships Distance run?*

In the Oblique Triangle ADE, Plate 3. Fig. 1.

Let A represent the Northernmost
D the Southernmost ——— } Port

The Side { AE the first ——— } Ship's Course and Distance
 { DE the second ——— }

E the Place where the two Ships meet.

Here are two Angles and one Side given, and therefore by Chap. 2. Sect. 3. Prob. 5. Case 1. of *Oblique-angles*, in Page 44.

1. For

Sect. V. *Plain Sailing, the third Part.*

1. For the Side AD , the Distance of the two Ports, the Proportion by *Axiom* the 2d, is,

$S. ADE \dots Side AE :: S. AED \dots Side AD.$

$S. 3. Points \dots 68 Min. :: S. 9 Points \dots Min. 120.5 Tenth.$

Note; When an Angle exceeds 8 Points, subtract it from 16; as here, 9 Points being subtracted from 16, the Remainder 7 Points, is to be used instead of it.

2. For the Side DE , the second Ship's Distance, the Proportion by the said *Axiom* is,

$S. ADE \dots Side AE :: S. DAE \dots Side DE.$

$S. 3 Points \dots 68 Min. :: S. 4 Points \dots Min. 86.2 Tenth.$

Prob. 2. Suppose two Ports lie NE. and SW. and a Ship sails from the Southermost ESE. 45 min. another from the Northermost runs 72 min. and then meets the first Ship; I demand the Course steer'd by the last, and the Distance of the Ports?

In the Oblique Triangle ADE *Plate 3. Fig. 2.*

Let A represent the Southermost } Port.
 D the Northermost ——— }

The Side { AE the first — } Ship's Course and Distance.
 DE the second }

E the Place where the Ships meet.

Here are two Sides and one Angle opposite given; and by *Chap. 2. Sect. 3. Prob. 6 Case 2 and 3. of Oblique-angles in Pages 44 and 45.*

1. For the Angle ADE the second Ship's Course, the Proportion by *Axiom* the 2d, is,

$Side DE \dots S. DAE :: Side AE \dots S. ADE.$

$72 Min. \dots S. 67d. 30m. :: 45 Min. \dots S. 35d. 15m.$ which subtract from $SW. 45d.$ makes the Course $9d. 45m.$ South Westerly, or S three quarters West.

2. For the Side AD , the Distance of the two Ports, the Proportion by the said *Axiom*, is,

$S. DAE \dots Side DE :: S. AED \dots Side AD.$

$S. 67d. 30m. \dots 72 Min. :: S. 77d. 15. \dots 76 Minutes.$

Prob. 3. Two Ships sail from a certain Road, one sails SSE. 50 Minutes, the other SSW. 35 Minutes. I demand their Bearing and Distance?

In the Oblique Triangle ADE . *Plate 3. Fig. 3.*

Let A represent the Road.

The Side { AD the first — } Ship's Course and Distance.
 AE the second }
 DE the Bearing and Distance of the two Ships.

Here are two Sides, and one Angle between them given; and by *Chap. 2. Sect. 3. Prob. 7. Case 4 and 5. of Oblique-angles in Page 45.*

1. For the Angles AED, and ADE; by *Axiom* the third.

Side {	A D 50 Min.	From the three Angles	180d. 00m.
	A E 35 Min.	Subtract the Angle DAE	45d. 00m.
Sum Sides	85 Min.	Sum of AED, and ADE	135d. 00m.

Diff. Sides 15 Min. The half Sum AED, and ADE 67d. 30m.

Sum Sides .. Diff. Sides :: T. $\frac{1}{2}$ Sum Angles .. T. $\frac{1}{2}$ Diff. Angles.

85 Minues .. 15 Min. :: T. 67d. 30m. .. T. 23d. 05m.

The half Diff. of the Angles 23d. 05m.

Added, is the greater Angle 90d. 25m. AED.

Subtracted, is the lesser Angle 44d. 25m. ADE.

which added to SSB. 22d. 30m. is South Easterly 66d. 55m. and North Westerly 66d. 55m. that is, E S E. and W N W. nearest, is the bearing of the two Ships.

2. For the Side DE, their Distance, the Proportion by the 2d *Axiom*.

S. ADE .. Side A E :: S. D A E .. Side DE required.

S. 44d. 25m. .. 35 Min. :: S. 45d. 00m. .. Min. 35.4 Tenths.

Problem 4. Suppose a Ship sails NE. 50 Leagues, then South Easterly 85 Leagues; and then forced back by foul Weather 105 Leag. to the Place from whence she first sailed: I demand her second Course, and her last Course back?

In the Oblique Triangle ADE, *Plate 3. Fig. 4.*

Let A represent the Place sailed from at first.

D } the { second Place, and Side DE the 2d Course and Dist.
E } the { third Place, and Side EA the 3d Course and Dist.

Here are three Sides given; and by *Chap. 2. Sect. 3. Prob. 8. Case 6. of Obliquangles, in Pages 46 and 47.*

1. For FE the Difference of the Segments AB, and BE; the Proportion according to the 4th *Axiom*, is,
Leagues,

Side {	DE 85	Side AE .. Sum DE & DA :: dif. DE & DA .. FE dif. Seg
	DA 50	105 leag. .. 135 Leagues :: 35 Leagues .. 45 Leag.
Sum	135	45 FE Difference of the Segments AB, and BE.
Diff.	35	150 } the half is { 75 BE the greater Segment.
	60	30 AB the lesser Segment.

Side AE — 105 Leagues.

2. For

2. For the Angles DAE and AED, the Proportion by the first Axiom, is,

Hypotenuse AD .. Radius :: Leg AB .. S.c. DAB or DAE.

50 Leagues S. 90d :: 30 Leag. .. S. 36d. 53m.

Subtract from _____ 90d. 00m.

Resteth Angle DAE _____ 53d. 07m. which being added to the N E. makes N. Easterly 98d. 07m. or South Easterly 81d. 53m. so that the Course from E to A, is W. by N. a quarter W. back to the Place first sailed from. And again ;

Hypotenuse DE .. Radius :: Leg BE .. S.c. BED, or AED.

85 Leagues .. S. 90d :: 75 Leag. .. S. 61d. 55m.

Subtract from _____ 90d. 00m.

Resteth the Angle AED _____ 28d. 05m.

Which subtract from the South Easterly 81d. 53m. leaveth 53d. 45m. or SE three quarters E. nearest, for the second Ship's Course from D to E.

These are the Kinds of Oblique Questions, tho' Multitudes may be proposed, of which here followeth a Taste, to exercise the Young Learner ; all of them to be resolved by the foregoing.

Prob. 5. Suppose a Merchant-ship in 45d. 30m. North Latitude, falls into the Hands of Pyrates, who take away his Sea-Compass ; after which, he saileth as directly as he can 67 Leagues between the South and West, and at the End of two Days meets a Ship of War, who also had been the Day before in 45d. 30m. North Latitude, and had sailed thence S E. by S. 39 Leagues ; now the Merchant-ship left those Pyrates lying to and fro where they robbed him, and the Man of War being desirous to find them ; I demand what Course he must shape to speak with them ?

Ans. North 61d. Easterly, or NE by E. half E. the Man of War must steer to find the Pirate.

For this Problem is an Oblique Triangle ; two Sides and one Angle opposite given ; to find the Angle opposite to the other Side ; which Triangle is thus made.

1. Describe a Circle with the Chord of 60 Degrees, and quarter it, on whose Diameter set N. E. S. W. and A at the Center ; but (always) N. at the upper part, and E at the Right-hand of the Circle.

2. Then lay 3 Points from S. towards E. on the Circle, and draw the SE by S. Line, (AD) 39 Leagues long.

3. With

3. With 67 Leagues, and one Foot on D, with the other cross the Line WAE (produced to the Eastward) in C, the Place where the Ship fell in with the Pyrates.

4. Then draw a Line from C to D, and it's done: For A and C are both in the Latitude of 45d. 30m. and the Side AD represents the Man of War's Course and Distance, and the Side CD the Merchant Man's after he lost his Compass, so that the Angle ACD being measured on the Scale of Chords, will shew her Course from the West, towards the South, the opposite Point is the Man of War's Course North Easterly, to find the Pyrates.

Problem 6. *Coasting along Shore, I saw two Capes of Land; the first did (by the Compass) bear N. the second WNW. then I stood away NW by N. 9 Minutes, until the first bore from me E by S. and the second S by E. the Bearing and Distance of them is required?*

Answ. South 38d. 05m. Westerly, or SW. by S. half W. and NE by N. half E. nearest, Distance is Minutes 6.22 Parts of a hundred.

Note, In all Questions of this Nature, you must, as preparative Work, find the Distance of each Cape from the Ship, at first seeing them, or at last setting them; which is evident by the Projection, thus;

1. Having drawn a Circle, quarter'd it, and placed the Letters N, S, E, W, and A; as directed in the last Problem, produce AN up higher, because the first Cape's Bearing is North.

2. Lay 6 Points from N, towards W, and draw the WNW. Line, for the second Cape's Bearing.

3. Lay 3 Points from N, towards W, and draw the N. W. by N. Line 9 Minutes long, from A to D, the Ship's Course and Distance.

4. Then lay 7 Points from S towards E, and laying a Scale on it and A, draw an E. by S. Line from D, parallel to the edge of the Scale, to cut the North Line in B, the first Cape.

5. In like manner, lay 1 point from S, towards E, and lay a Scale on it, and A, draw a S by E. Line from D, parallel to the edge of the Scale, to cut the WNW. Line in C, the second Cape.

6. Draw a Line from B to C, and it's done: For the Line BC represents the Bearing and Distance of the two Capes, from each other, which being measured on the same Scale, the Side AD was taken from, will shew their Distance afunder. And the Angle

Angle ABC, measured on the *Scale of Chords or Rumbs*, will shew their Bearing, which is South Westerly, and North Easterly.

But to find these Things by Trigonometry, it's necessary to find the Sides AB and AC; or else the Sides DB and DC; which is done in two Oblique Triangles ABD, and ACD, in each, all the Angles, and one Side is given, to find a Side.

And Note. A represents the Place of the Ship at first seeing the Capes, and D the Place of last setting them.

So that, when the Sides AB and AC, or DB and DC, are found; then is there either the Oblique Triangle BAC, or BDC to work in; then BC (the Side common to both Triangles) with its agreeing Angles may be found, by which their Bearing and Distance from each other is discovered: And in each Triangle there is two Sides and one Angle between them given, to find the other Angles, and third Side; which is to be wrought as the third Problem of this Section.

Problem 7. *Suppose a Ship sailing N. W. two Islands appear in sight, one bears WNW. the other N. from the Ship, and when the Ship hath sailed 6 Minutes further, the first bears W by S. and the other NE. Their Bearing and Distance is required?*

Ans. South 58d. 46m. Westerly, or SW by W. a quarter W. and NE by E. a quarter E. Distance is Minutes 9.7 Tenths. found out as before, in the last Problem.

Prob. 8. *Three Ships sail from one Port, the first sails SW. by W. the second W by S. half W. and the third NW by W. 8 min. then the first bears from the third S by W. the second bears from the third SSE. The first and second Ship's Distance sailed, and their Bearing and Distance from each other is required?*

Ans. First Ship's Distance Minutes 10.45, second's Distance Minutes 4.65, their Bearing North 37d. 14m. Easterly, or NE. by N. a quarter E. and SW by S a quarter W. Distance Minutes 6.75. This also is wrought by the Direction of the 6th Problem.

Prob. 9. *Admit sailing along Shore, I see two Headlands, the Eastermost bears NNE. and the Westermost NW. off me, at the same time an Island bears S. then after I sailed W. 8 Minutes the first did bear NE by E half E. the second NNE. and the Island ESE. from me: The Bearing and Distance of these Places from each other is required?*

Ans. The Head-lands bear North 88d. 53m. Westerly, or East

East and West nearest, Distance Minutes 7.95. The Eastermost Head-land bears from the Island, North 14d. 30m. East, or N. by E. a quarter E. and S by W a quarter W. Distance Minutes 9.15, and the Westermost Headland bears from the Island, North 32d. 15m. West, or N W by N. and S E by S. Distance Minutes 10.6 Tenths.

This is of the same Nature with the 6th Problem, only here are three Things to be found as preparative, *viz.* the Distance of each Headland, and the Island from the Ship, and consequently in three Triangles both in the preparative, and subsequent Work, Proportions are made, which makes up nine several Statings, to resolve this Problem.

The next 4 Problems are used in turning to Windward.

Problem 10. *Suppose the Wind South, and a Ship is bound to a Port 400 Leagues directly to Windward, and makes her way good within $6\frac{3}{4}$ Points of the Wind. I demand her Distance sailed upon each Tack, to gain the said Port?*

Ans. 823 Leagues, is the Ship's Distance sailed on each Tack. For it's projected by the Plain-Scale.

1. Describe a Circle with the Chord of 60 Degrees, quarter it, and place N.E.S.W. and A, as directed in Problem 5.

2. Lay 400 Leagues on the Meridian, from A (Southerly) to B, the place the Ship is bound unto.

3. From S. lay $6\frac{3}{4}$ Points towards E, and by it from A, draw the ESE $\frac{3}{4}$ E. Line AC.

4. Also lay $6\frac{3}{4}$ Points from S, towards W, and laying a Scale on it and A, draw a WSW. $\frac{3}{4}$ W. Line from B, parallel to the edge of the Scale, to cut the ESE $\frac{3}{4}$ E. Line in C, the Place where the Ship tack'd, and it's done.

For, A represents the Place the Ship sail'd from, B the Port 400 Leagues directly to Windward, AC equal to CB, the Ship's Distance sail'd on each Tack; which being measured on the same Scale AB was taken from, will shew how much it is.

But to work it by Trigonometry, in the Oblique Triangle ABC, all the Angles and one Side AB being given, the other Sides AC and CB are found as in the First Problem of this Section: And because two Angles are equal, the Sides opposite to them are also equal; therefore one Proportion finds AC and CB.

Prob

Prob. 11. *The Wind SW. and a Ship plying to Windward, (making one or many Boards) having run 900 Leagues; that is, 450 with the Larboard Tack aboard, and 450 with her Starboard Tack aboard, it got 300 Leagues directly to Windward: I demand how near the Wind she makes her Way?*

Ans. 70d. 32m. or 6 Points and a quarter from the Wind. Which is thus delineated by the *Plain Scale*.

1. A Circle being describ'd, quarter'd, and letter'd, as hath been directed in the former Problems; then lay 4 Points, from S, towards W, and by it and A, draw a (SW.) Line 300 Leagues long, from A to B.

2. With 450 Leagues (taken from the same Scale AB was taken from) and one Foot on A, make an Arch; also with the same, and one Foot on B, cross the former Arch in C.

3. From C, draw Lines to A and B, and it's done: For the Angle BAC, equal to the Angle ABC, measured on any Scale of Chords, sheweth how near the Wind the Ship makes her way.

But by Trigonometry, thus: In the Triangle ABC, all three Sides are given, to find the Angles, which may be done by the Fourth Problem of this Section. But, because the Sides AC and BC are equal, therefore let fall a Perpendicular from C to the SW. Line AB, as AD, which cuts AB in the middle, making AD 150 Leagues equal to BD, and so reduce the Oblique Triangle ABC into two equal Right-angled Triangles, ADC and BDC; whose Sides, and Angles in each Triangle are equal to one another; so that one Proportion serveth to answer the Question.

For in the Right-Angled Triangle ADC, there is given the Hypotenuse AC 450 Leagues, and Leg AD 150 Leagues; to find the Angle CAD which is equal to the Angle CBD (the Ship's Course from the Wind) which is done by Note 2. of Axiom 1. of *Plain Trigonometry*, thus,

Hypot. AC .. Radius :: Leg A D .. S. ACD = BCD

450 Leag. .. S. 90d. :: 150 Leag. .. S. 19d. 28m.

Which subtract from _____ 90d. 00m.

Remainder is the Angle CAD = ABC 70d. 32m. or 6½ pts
the Ship's Course from the Wind SW.

Prob.

East and West nearest, Distance Minutes 7.95. The Eastermost Head-land bears from the Island, North 14d. 30m. East, or N. by E. a quarter E. and S by W a quarter W. Distance Minutes 9.15, and the Westermost Headland bears from the Island, North 32d. 15m. West, or N W by N. and S E by S. Distance Minutes 10.6 Tenths.

This is of the same Nature with the 6th Problem, only here are three Things to be found as preparative, *viz.* the Distance of each Headland, and the Island from the Ship, and consequently in three Triangles both in the preparative, and subsequent Work, Proportions are made, which makes up nine several Statings, to resolve this Problem.

The next 4 Problems are used in turning to Windward.

Problem 10. *Suppose the Wind South, and a Ship is bound to a Port 400 Leagues directly to Windward, and makes her way good within $6\frac{3}{4}$ Points of the Wind. I demand her Distance sailed upon each Tack, to gain the said Port?*

Ans. 823 Leagues, is the Ship's Distance sailed on each Tack. For it's projected by the Plain-Scale.

1. Describe a Circle with the Chord of 60 Degrees, quarter it, and place N.E.S.W. and A, as directed in Problem 5.

2. Lay 400 Leagues on the Meridian, from A (Southerly) to B, the place the Ship is bound unto.

3. From S. lay $6\frac{3}{4}$ Points towards E, and by it from A, draw the ESE $\frac{3}{4}$ E. Line AC.

4. Also lay $6\frac{3}{4}$ Points from S, towards W, and laying a Scale on it and A, draw a WSW. $\frac{3}{4}$ W. Line from B, parallel to the edge of the Scale, to cut the ESE $\frac{3}{4}$ E. Line in C, the Place where the Ship tack'd, and it's done.

For, A represents the Place the Ship sail'd from, B the Port 400 Leagues directly to Windward, AC equal to CB, the Ship's Distance sail'd on each Tack; which being measured on the same Scale AB was taken from, will shew how much it is.

But to work it by Trigonometry, in the Oblique Triangle ABC, all the Angles and one Side AB being given, the other Sides AC and CB are found as in the First Problem of this Section: And because two Angles are equal, the Sides opposite to them are also equal; therefore one Proportion finds AC and CB.

Prob.

Prob. 11. *The Wind SW. and a Ship plying to Windward, (making one or many Boards) having run 900 Leagues; that is, 450 with the Larboard Tack aboard, and 450 with her Starboard Tack aboard, it got 300 Leagues directly to Windward: I demand how near the Wind she makes her Way?*

Ans. 70d. 32m. or 6 Points and a quarter from the Wind. Which is thus delineated by the *Plain Scale*.

1. A Circle being describ'd, quarter'd, and letter'd, as hath been directed in the former Problems; then lay 4 Points, from S, towards W, and by it and A, draw a (SW.) Line 300 Leagues long, from A to B.

2. With 450 Leagues (taken from the same Scale AB was taken from) and one Foot on A, make an Arch; also with the same, and one Foot on B, cross the former Arch in C.

3. From C, draw Lines to A and B, and it's done: For the Angle BAC, equal to the Angle ABC, measured on any Scale of Chords, sheweth how near the Wind the Ship makes her way.

But by Trigonometry, thus: In the Triangle ABC, all three Sides are given, to find the Angles, which may be done by the Fourth Problem of this Section. But, because the Sides AC and BC are equal, therefore let fall a Perpendicular from C to the SW. Line AB, as AD, which cuts AB in the middle, making AD 150 Leagues equal to BD, and so reduce the Oblique Triangle ABC into two equal Right-angled Triangles, ADC and BDC; whose Sides, and Angles in each Triangle are equal to one another; so that one Proportion serveth to answer the Question.

For in the Right-Angled Triangle ADC, there is given the Hypotenuse AC 450 Leagues, and Leg AD 150 Leagues; to find the Angle CAD which is equal to the Angle CBD (the Ship's Course from the Wind) which is done by Note 2. of Axiom 1. of *Plain Trigonometry*, thus,

Hypot. AC .. Radius :: Leg A D .. S. ACD = BCD

450 Leag. .. S. 90d. :: 150 Leag. .. S. 19d. 28m.

Which subtract from _____ 90d. 00m.

Remainder is the Angle CAD = ABC 70d. 32m. or 6½ pts
the Ship's Course from the Wind SW.

Prob.

Prob. 12. *Admit a Ship bound to a Port that lieth SW by S. 484 Leagues Distance, the Wind S. by E. and makes her way good within 6 Points of the Wind. I demand how far she must sail upon each Tack, to gain the Port?*

Answer 690 Leagues on her Larboard Tack, and 328 Leagues on her Starboard Tack, to arrive at the Port, which is thus demonstrated by the Plain Scale.

1. The Circle describ'd, quarter'd, &c. as formerly, lay one Point from S, towards E, and by it and A draw a S by E Line AB, representing the Wind.

2. From S, towards W, lay 3 Points, and by it and A, draw a SW by S. Line 484 Leagues long, from A to C.

3. From the Wind (S. by E.) lay $6\frac{1}{2}$ Points towards W, and by it and A, draw a (SW by W $\frac{1}{4}$ W.) Line AD.

4. Likewise lay $6\frac{1}{2}$ Points from the Wind (S. by E.) towards E, on which Punct and A, lay a Scale; then from C draw an (E. by S. $\frac{1}{4}$ E.) Line to cut the Wind, (S by E.) Line in B, and the SW by W. $\frac{1}{4}$ W. Line in D, and it's done. For AD, and DC represent the Ship's Distance sailed on each Tack, which being measured on the same Scale AC was taken from, will shew how much the Distance sail'd on each Tack is.

By Trigonometry it's thus: In the Oblique Triangle ACD, all the Angles and one Side is given; to find the other two Sides, which is done by the first Problem of this Section, in Page 71.

As S. ADC .. Side AC :: S. ACD .. Side AD.

S. $3\frac{1}{2}$ Points .. 484 leag. :: S. $10\frac{1}{4}$ Points .. 690 Leagues, is the Ship's Distance sail'd on her Larboard Tack.

As S. ADC .. Side AC :: S. CAD .. Side CD.

S. $3\frac{1}{2}$ Points .. 484 leag. :: S. $2\frac{1}{4}$ Points .. 328 Leagues, is the Ship's Distance sail'd on the Starboard Tack.

Problem 13. *If two Ports lie SW by S. and NE by N. Distance 484 Minutes, the Wind S by E. and a Ship sails from the Northernmost Port, close upon a Wind 695 Minutes, with her Larboard Tack aboard, and 332 with her Starboard Tack aboard, and then arrives at the Southernmost Port. I demand how near the Wind she makes her way good upon each Tack?*

Ans. 70d. 30m. on one Tack, and 70d. 40m. on t'other; which is $6\frac{1}{2}$ Points from the Wind; that is SW by W. $\frac{1}{4}$ W. with her Larboard Tack, and E by S. $\frac{1}{4}$ E. with her Starboard Tack. Which

Which is thus demonstrated by the *Plain Scale*.

1. Describe a Circle with a Chord of 60 Degrees, quarter it, &c. as formerly, then lay three Points from S, towards W, and by it and A, draw a SW by S Line 484 Minutes long, from A to B.

2. Lay 1 Point from S, towards E, and by it and A, draw the S by E. Line AC.

3. With 695 Minutes (taken from the same Scale AB was taken from) and one Foot on A, make an Arch; also with 332 Minutes, and one Foot on B, cross the former Arch in D.

4. From D, draw Lines to A and B, and continue the Line BD, 'till it cuts the S. by E. Line AC in C, and it's done: For the Angles DAC, and ACD measured on the Scale of Chords or Rumbs, will shew how near the Wind the Ship makes her Way good on each Tack.

By Trigonometry it's thus: In the Oblique Triangle ABD, all the three Sides are given, to find the Angles; that is, the Side AD 695 Minutes, Side AB 484, and Side BD 332; to find the Angles BAD, and BDA; which is done by the Fourth Problem of this Section, in Pages 72 and 73.

The next Problems are concerning Currents.

Prob. 14. Suppose a Current sets N N E. 7 Minutes in a certain time, and a Ship sails SSW. (by the Log) 9 Minutes in the same time: What is her true Course and Distance?

Ans^w SSW. is the Ship's true Course, and Distance 2 Minutes: Which is evident by the Plain Scale, thus;

1. Having done as formerly directed, in making a Circle, &c. Lay 2 Points from S, towards W, and by it and A draw a SSW. Line 9 Minutes long, from A to B.

2. With 7 Minutes (taken from the same Scale AB was taken from) and one Foot on B, cross the Line AB in C, so that BC may be NNE. and it's done: For AC measured on the same Scale, sheweth the Ship's true Distance. Or thus,

From the Ship's supposed Distance SSW. 9 Min. AB.

Subtract the Current's Motion NNE. 7 Min. BC.

Remains the Ship's true Distance SSW. 2 Min. AC.

The like is done for the two next following Problems.

Prob. 15. If a Current sets E. 4 Min. an Hour, a Ship sails E. (by the Log) 5 minutes in an Hour: The Ship's true Course and Distance is required?

Ans^w. The Ship's true Course is East, Distance 9 Minutes.

Prob.

Prob. 16. A Current setting WSW. 90 Minutes in a known time, and a Ship sailing ENE. (by the Log.) 60 Minutes in the same time: What is her true Course and Distance?

Ans. WSW. 30 Minutes; so that she is fallen a Stern.

Prob. 17 Suppose a Current setteth E. 2 Minutes an Hour, and a Ship sails S. 60 Minutes an Hour: What's her true Course and Distance?

Ans. South 18d. 26m. Easterly, or S by E. $\frac{3}{4}$ E. is the Ship's true Course, Distance Minutes $6\frac{1}{4}\sigma$.

By the Plain-Scale, it's thus demonstrated.

1. After a Circle is described, &c. as formerly, then lay 6 Minutes on the Meridian from A to B.

2. Draw BC parallel to W A E, and thereon lay 2 minutes from B (towards the Right-hand) to C.

3. Then draw a Line from A to C, and it's done; for the Angle B A C is the Ship's true Course, and the Side A C her true Distance.

By Trigonometry it's thus: The Triangle ABC is a Right-angled Triangle, in which both Legs are given, the Leg AB 6 Minutes, the Ship's supposed Distance, and the Leg BC 2 Minutes, the Current's Motion, to find the Angle BAC the Ship's true Course, and the Hypotenuse AC her true Distance; which is done by Axiom the First, and Note 1, and 2. of Plain Trigonometry, in Page 36.

In like manner, Problem 18 and 19 are performed.

Prob. 18. If a Ship sails (five Days together) by the Log, SW. 725 Minutes: In a Current that setteth (in the same time) SE. 280 Minutes: What's the true Course and Distance?

Ans. South 23d. 52m. Westerly, or SSW. is the Ship's true Course, Distance 775 Minutes.

Problem 19. Admit a Ship sails W. 730 Minutes, thwart a Current setting to the Southward; and then, by Observation findeth the Difference of Latitude is 4d. or 240 Minutes. I demand her true Course and Distance?

Ans. South 71d. 48m. Westerly, or WSW. $\frac{1}{4}$ W. is the Ship's true Course, Distance 768 Minutes.

Problem

Problem 20. *If a Ship sails S. by E. 36 Minutes in a Current, and then arrives at a Port which lieth from the Place she departed from S. E. by S. Distance 54 Minutes: I demand the Current's Motion both in Quality and Quantity; that is, How it setteth, and how fast?*

Answer. The Current setteth South 67d. 20m. East, or E. S. E. is the Drift of the Current as to Quality, and Minutes 24.9 Tenths is its Drift as to Quantity. And is demonstrated by the Plain Scale, after this manner;

1. As before, having described a Circle, &c. Lay 1 Point from S. toward E. and by it and A, draw a S. by E. Line 36 Minutes long, from A to B.

2. Lay 3 Points from S. towards E. and by it and A, draw a S. E. by S. Line, 54 Minutes long, from A to C.

3. Then draw a Line from B to C, and it's done: For the Angle ACB measured (on the Scale) sheweth the Current's Motion as to it's Quality, which Way from the S. E. by S. and the Side BC measured (on the Scale) sheweth the Current's Motion, as to its Quantity, how much, or how fast.

But by *Plain Trigonometry*, 'tis thus,

In the Oblique Triangle ABC, there is given, two Sides, and an included Angle; that is, the Side AC 54 Minutes, the Side AB 36 Minutes, and the Angle BAC two Points, equal to 22d. 30m. to find the Angles ABC, ACB, and the Side BC; which is wrought by *Axiom* the third, and is like the third *Problem* of this Section.

Problem 21. *Suppose a Ship sails from a certain Cape, or Headland, and (by the Log) in 24 Hours, runneth S S. W. 49 Minutes, in a Current setting between the N. and the W. and then the Cape did bear ENE. from the Ship, and by Observation, the Difference of Latitude was 30 Minutes; I demand the Current's Motion; that is, upon what Point of the Compass, and how fast?*

Answer. The Current sets North 74d. 7m. West, or WNW half W. nearest, and at the Rate of Minutes 2.32 an Hour, and is thus demonstrated by the Plain Scale.

1. After the Circle is described, quarter'd, &c. lay two Points from S. towards W. and by it and A, draw a S. S. W. Line 49 Minutes long, from A to B.

2. Lay 6 Points S. towards W. and by it and A, draw a WSW. and ENE. Line AC.

F

3. Lay

3. Lay 30 Minutes (on the Meridian) from A to D, and from D draw a West Line Parallel to AW, to cut the WSW. Line in C.

4. Then draw a Line from B to C, and it's done: For the Angle ABC being measured on the Scale, sheweth the Current's Motion from SSW. and the Side BC being measured sheweth how much the Current set the Ship.

By Plain Trigonometry, it's thus;

1. In the Right Angle Triangle ADC, there is given, the Leg AD 30 Minutes, Angle DAC 6 Points, and Angle ACD 2 Points; to find the Hypotenuse AC, which is done by *Axiom First of Plain Trigonometry*.

2. Then in the Oblique Triangle ABC, there is given, the Side AB 49 Minutes, the Side AC found before, and the included Angle BAC 4 Points, equal to 45d. to find the Angle ABC, (the Current's Motion from S. S. W.) and the Side BC, it's Motion how much, which is solved by *Axiom the 3d*, as was the last Problem.

Let this suffice, for the *First Part of Navigation*, commonly called *Plain Sailing*, (tho' many more Problems might be invented.) *Wright's-Sailing* is next in order.

CHAPTER IV.

The Second Part of Navigation, or the Doctrine of Plain Right-Angle-Triangles, applied in Problems of Mr. Wright's Sailing (vulgarly) called MERCATOR'S SAILING.

IT'S necessary to describe Mr. *Wright's Chart*, and shew the Uses thereof, before the Problems of Sailing by it, which by this Method will be the easier understood.

Section I. *The Description and Use of Mr. Wright's-Chart.*

THIS Projection supposeth the Earth and Sea to make one round Body or Globe: In order to the right understanding of which, observe the following Definitions.

1. Upon this Earthly Globe are imagined two opposite Points, one called the North Pole, the other the South Pole; as P, and I. *Plate 5. Fig. 1.*

2. In the Middle between those two Poles, or equally distant from each, is drawn a Circle round the Globe, called the *Equator*;

Equator, from which, Latitude taketh it's Beginning, and in which, Longitude is reckon'd; as *EAQ*.

3. Any Circle drawn through both Poles, is called a Meridian, as *PMI*, *PNI*, &c. answerable thereunto is any North or South Line drawn in the Chart.

4. Those Circles which are parallel to the Equator, are called Parallels of Latitude; as *alt*, *Zlt*, &c. and are represented in the Chart by the East and West Lines.

5. Latitude of a Place, is the (nearest) Distance of any Parallel passing over it from the Equator; from thence counted both Ways to each Pole, ending in 90 Degrees, the greatest Latitude.

6. North Latitude, is on that Side the Equator towards the North Pole, and South Latitude on the other Side of Equator, towards the South Pole.

7. Difference of Latitude, is the (nearest) Distance between any two Parallels, and sheweth how far one Place is to the Northward or Southward of another, it never exceeds 180 Degrees.

8. Longitude, is reckon'd in the Equator, round which (by some) it's counted encreasing to the Eastward, 'till it end (where it first began) in 360 Degrees, the greatest Longitude: Others (as Mr. Wakely, in his *Mariner's Compass Rectified*) reckon it from one Meridian, both Easterly and Westerly, till both Accounts meets at 180 Degrees in the opposite Meridian, as in the aforesaid Book, Longitude begins at the Meridian of London, and from thence is counted Easterly, East Longitude 180 Degrees; and Westerly, West Longitude 180 Degrees, at which both Longitudes end.

9. Difference of Longitude, is that Distance or Portion of the Equator contained between the Meridians of any two Places, and sheweth (in the Equator) how far the Meridian of one Place, is to the Eastward or Westward of the Meridian of another, and never exceeds 180 Degrees.

From these Definitions, or Principles, there must necessarily follow these Theorems.

1. The Distance of any two Meridians, in any Parallel of Latitude, is less than their Distance in the Equator, because all Meridians on the Globe meet in the Poles.

2. The Degrees of Longitude diminish towards each Pole; and the nearer the Pole, the less they are, because the Meridians approach nearer to one another, the farther you sail from the Equator, towards either Pole.

3. The Degrees of Latitude are equal in all Places or Parts of the Globe.

4. The Plain Chart, which counteth the Degrees (as well of Longitude, as of Latitude) in all Places to be equal, is notoriously False.

5. Mr. *Wright's* Projection (commonly known by the Name of *Mercator's-Chart*) wherein, (though the Degrees of Longitude are equal, having the Meridians parallel to one another) the Degrees of Latitude are enlarged towards each Pole, in the same Proportion as the Degrees of Longitude diminish on the Globe, will in all Respects agree with the Globe, and is a true Way of Sailing.

These *Definitions* and *Theorems* duly consider'd, there needs no more for the Description of this Chart, it having only this Difference from the Plain Chart, before describ'd in *Chap. 3. Sect. 2. Page 53.* that the Equator is divided, and number'd in Degrees, as the graduated Meridian is, and without any farther Description, the Uses are as follow.

Problem 1. To find the Latitude of any Place in the Chart.

This was taught before (in the Use of the *Plain Chart*) in *Page 54.* and needs no further Rule or Example.

Problem 2. To find the Longitude of any Place in the Chart.

The Rule 1. Take the nearest Distance from the proposed Place, to any Meridian.

2. Move the Compasses (being kept at that Distance with one Foot on the Meridian, 'till both Feet come to the Equator, and the Foot which stood on the proposed Place sheweth its Longitude required.

Example. I demand the Longitude of the Lizard in England?

Answer. 9d. 40m. according to the old Way of computing the Longitude from the Meridian of *Pico Teneriff*; But 5d. 24m. West Longitude, counting East and West Longitude, from the Meridian of *London*, according to the *Mariner's Compass Rectified*.

Note;

Note, Some Charts begin Longitude at the *Lizard*, counting from thence Eastward and Westward, 180 Degrees.

Problem 3. *To find the Course, or Bearing of any two Places in the Chart.*

This is done as before, in the Use of the Plain Chart, in Page 55, and needs no Example.

Problem 4. *To find the Distance of any two Places in the Chart.*

In this Problem are four Cases; the two Places may be situated under one Meridian, under the Equator, or in one Parallel, or they may differ both in Latitude and Longitude.

Case 1. *Two Places under one Meridian, (that is, differing only in Latitude) being given, to find their Distance.*

The Rule. Find the Difference of Latitude between the two given Places, and 'tis the Distance required.

How to find the Difference of Latitude between the two Places, has been taught in *Chap. 3. Sect. 3. of Plain Sailing*, in Page 58.

Case 2. *Two Places in the Equator given, to find their Distance.*

The Rule. Find the Difference of Longitude between them, and 'tis the Distance required.

How to find the Difference of Longitude, will be shewed in the next *Section*, in Page 89.

Case 3. *Two Places in one Parallel, (that is, differing only in Longitude) being given, to find their Distance.*

The Rule. 1. Take the Distance between the given Places in the Compasses.

2. Lay that Distance on the graduated Meridian, so that one Foot may be as many Degrees above the Parallel of the given Places, as the other below it, there stay the Compasses.

3. Count the Degrees between the Feet of the Compasses, and 'tis the Distance required.

Example. *I demand the Distance from the Lizard in England, to Pengwin Island on the Coast of Newfoundland, both being in the Latitude of 50d. 00m. North, or near it.*

Here, the Distance from the *Lizard* to *Penguin* Island, applied to the Meridian as directed, will reach from 36d. 30m. to 63d. 30m. the latter being as much above 50d. 00m. as the former is below it; and the Degrees intercepted are 27, or 540 Leag. which is the Distance required. Or thus,

Take the Length of a Degree in the given Latitude, as here from 49d. 30m. to 50d. 30m. turn that over in a straight Line, from the *Lizard* to *Penguin* Island, and it's 27 times; which shews the Distance 27 Degrees as before.

Case 4. Two Places differing in Latitude and Longitude, being given, to find their Distance.

The Rule. 1. Take their Difference of Latitude from the Equator.

2. Lay a Ruler on both given Places, apply that Distance to the Ruler's Edge, that when one Foot is placed close to the Ruler, and the other turned about, it may just touch some East and West Line, crossed by the said Ruler's Edge, there stay the Compasses.

3. Then the Distance (by the Ruler's Edge) from the Place where the Compasses rested, to that Place where the Ruler crosseth the aforesaid East and West Line, measured on the Equator, giveth the Distance required.

Example.

I demand the Distance from the Lizard to the Island Barbadoes?

The *Lizard's* Latitude is — 50d. 00m. } by Problem 1.
And *Barbadoes* Latitude is — 13d. 00m. }

Their Difference of Latitude — 37d. 00m.

Then take their Difference of Latitude 37 Deg. from the Equator, and laying a Ruler on both Places, apply one Foot of the Compasses to the Ruler's Edge, that turning the other about, it may touch an East and West Line, crossed by the Ruler; then the Distance (by the Ruler's Edge) from the Place where the Compasses rested, to the Place where the Ruler crossed the aforesaid East and West Line, measured on the Equator, is 56d. 45m. or 1135 Leagues, the Distance required.

And here observe; the Meridian Line, and Line of Equal Parts next one another on the *Gunter's* Scale, the first is, or may be the Meridian Line, and Degrees of Latitude in a *Mercator's* Chart; the latter, the Equator-Line, and Degrees of Longitude.

Thus

Thus much for the Use of *Mercator's-Chart*, Problems of sailing by it are next; but first some preparatory Problems in *Geography*.

Section II. *Some necessary Geographic Problems useful in Mercator's-Sailing.*

THESE Problems properly belong to *Geography*, but are necessary in sailing by Mr. *Wright's* (commonly called *Mercator's*) Chart, and for that Reason are placed here.

Note; That all the Places mentioned in this Book, their Latitudes and Longitude were taken from a Chart, Intituled, *A new and exact Chart, containing the Sea-Coast of Europe, Africa, and America; from England to Cape Bona Esperance, and from New-found-land to the Straits of Megellan, according to Mr. Edward Wright's Projection, and Published by William Mount and Thomas Page, on Tower-Hill.*

This Chart has been new made, and lately corrected, wherein the Longitude of Places is reckoned from the Meridian of *London*, agreeing with the *Mariner's-Compass rectified*: As for the disagreement that may be found between it and Tables of Latitude and Longitude in other Books, 'tis not to be regarded; because the Tables themselves considerably differ from one another, as may appear by the following Problems.

Problem 1. The Latitudes of two Places given; to find their Difference of Latitude.

Rule 1. If the two Places are upon the same Side of the Equator, that is, both in North Latitude; or both in South Latitude; subtract the less Latitude from the greater, the Remainder is the Difference of Latitude.

Rule 2. If one Place be on one Side of the Equator, and the other Place on t'other Side; that is, one Place in North Latitude, the other in South; add the two Latitudes together, and the Sum is the Difference of Latitude.

Observe 1. If a Ship sails from a great North Latitude to a less, she sails Southerly; and if a Ship sails from a less North Latitude to a greater, she sails Northerly, which is called raising the Pole.

2. If a Ship sails from a great South Latitude to a less, she sails Northerly ; but if she sails from a less South Latitude to a greater, she sails Southerly.

3. When a Ship crosses the Equator, and sails from North Latitude into South, the Difference of Latitude is Southerly ; or, if she sails from South Latitude into North, she sails Northerly.

Example 1. *I demand the Difference of Latitude between the Lizard, and Island Barbadoes ?*

The Lizard } Latitude { ——— 50d. 00m } North.
I. Barbadoes } { ——— 13d. 25m }

Their Diff. of Latitude by Subtraction is 36d. 35m. equal to 2195 Minutes.

Example 2. *To find the Difference of Latitude between the Island Barbadoes and Island St. Helena.*

Island { Barbadoes } in Latitude { ——— 13d. 25m North
{ St. Helena } { ——— 16d. 03m South

Their Diff. of Latitude by adding, is 29d. 28m equal to 1768 Minutes.

Problem 2. *The Latitude of one Place, and the Difference of Latitude between that and another Place being given, to find the Latitude of the latter Place, or Latitude the Ship is in ?*

The Rule.

The Latitude, and Difference of Latitude given, being of One } Name their { Sum } is the Latitude required.
a contrary } { Diff. }

Or' thus, in two Rules.

Rule 1. In { North } Lat. sailing to the { North } ward, add the Difference of Latitude to the given Latitude, the Sum is the Latitude required, of the same Name.

Rule 2. In { North } Lat. sailing to the { South } ward, subtract the less from the greater, the Remainder is the required Latitude of the same Name with the greater.

Example

Example 1. Sailing from the *Island Barbadoes* North Eastward, until the Difference of Latitude be 372 Leagues; What Latitude is the Ship in?

I. *Barbadoes*, Latitude is ——— 13d. 25m. North.

The Difference of Lat. 372 Leag. or 18d. 36m. Northerly.

Add, is the Latitude the Ship is in— 32d. 01m. Northerly.

Example 2. From the *Lizard*, a Ship sails South Westward, until the Difference of Latitude be 137 Leagues; What Latitude is the Ship in?

The *Lizard*, Latitude is ——— 50d. 00m. North.

The Difference of Lat. 137 Leag. or 6d. 51m. Southerly.

The Lat. the Ship is in by Sub. is ——— 43d. 09m. North.

Example 3. From *St. Helena* a Ship sails North Westward, until the Difference of Latitude be 419 Leagues; What Latitude is the Ship in?

I. *St. Helena*, Latitude is ——— 16d. 03m. South.

The Difference of Lat. 419 Leag. or 2cd. 57m. Northerly.

Latitude the Ship is in ——— 4d. 54m. North.

Problem 3. The Longitude of two Places given; to find their Difference of Longitude.

1. According to the old Way of counting the Longitude, The Rule is thus,

Subtract the less Longitude from the greater, the Remainder (if less than 180 Degrees) is the Difference of Longitude; but if the Remainder be more than 180 Degrees, subtract it from 360 Degrees, the last Remainder is the Difference of Longitude.

2. According to the new Way of counting the Longitude, in the *Mariner's-Compass Rectified*, the Rule is thus;

If both Longitudes be East, or both West, subtract the less from the greater, the Remainder is the Difference of Longitude; but if one be East, and the other West, add them together, and the Sum (if it exceed not 180 Degrees) is the Difference of Longitude; and when the Sum doth exceed 180 Degrees, subtract it from 360 Degrees, the Remainder is the Difference of Longitude required.

Example

Example 1. I demand the Difference of Longitude, between the Lizard and Island Teneriffa, one of the Canary Islands?

	d. m.
According to the old Account, Long. of { Lizard is	9 42
	} I. Teneriffa, 0 00
Their Difference of Longitude by Subtracting is	9 42
According to the Mar. Compass, Lon. of { Lizard is	5 24 W.
	} I. Teneriffa 17 05 W.
Their Difference of Longitude by Subtraction, is	11 41 W.

The Difference of Longitude between these two Places, are very different in several Books, therefore all in this Book are taken from the *Chart* aforesaid, or from the *Mariner's Compass Rectified*

Example 2. What's the Difference of Longitude between the Lizard, and I. Barbadoes?

By the *Mariner's Compass* Longit. of { Lizard is -- 5d. 24m. W.
 { I. Barbadoes 58d. 04m. W.
 Subtract, is the Difference of Longitude ——— 52d. 40m. e.
 equal to 3160 Minutes.

Problem 4. To know when the Difference of Longitude between any two Places, is Easterly, or Westerly.

1. **A**CCORDING to the old Way of Counting the Longitude, the Rule is thus;

If the Remainder (first found) be less than 180 Degrees, and you are bound to that Place, which hath (of the two) the greater Longitude, then is the Difference of Longitude Easterly; but if you are to sail to the less, it's Westerly; And when the first Remainder is more than 180 Degrees, it's just the contrary.

2. According to the *Mariner's Compass Rectified*, The Rule is thus;

When the Longitude of the two Places are both East or both West, and you are to sail to the greater Longitude; then the Difference of Longitude is (according to the Name of the Longitude) East or West. But if bound to the less Longitude, then is the Difference of Longitude contrary, that is, West in East Longitude, and East in West Longitude: And if one Place lies in East Longitude, and t'other in West, the Difference of Longitude between them, is according to the Name of that Longitude you are bound unto, that is, East, if to East Longitude; and West, if to West Longitude.

Prob.

Problem 5. *The Longitude of one Place, and the Difference of Longitude between that and another Place, being given; to find the Longitude of the last Place, or the Longitude the Ship is in.*

i. **A** According to the old Way of counting the Longitude, the Rules are these following,

Rule 1. Sailing to the Eastward; add the Longitude, and the Difference of Longitude together, the Sum, (but if it exceeds 360 Degrees, subtract 360 Degrees therefrom, the Remainder) is the Longitude the Ship is in.

Rule 2. Sailing to the Westward, subtract the Difference of Longitude, from (but if the Difference of Longitude be the greatest, add 360 Degrees to) the Longitude of the first Place, the Remainder is the Longitude the Ship is in.

2dly, According to the new Way of counting the Longitude in the *Mariner's Compass*; the Rules are these;

Rule 1. In East Longitude, sailing to the Eastward, and in West Longitude, sailing Westerly; add, gives the Longitude the Ship is in, (if it exceeds not 180 Degrees) agreeing with the Name of the first Place; but if it doth exceed, subtract it from 360 Degrees, the Remainder is the Longitude the Ship is in, of a contrary Name to the first.

Rule 2. In East Longitude, sailing Westerly, and in West Longitude, sailing Easterly; subtract, gives the Longitude the Ship is in, whose Name agrees with the greater.

Example 1. Sailing from *Barbadoes* North Easterly, 'till the Difference of Longitude be 275 Leagues, What Longitude is the Ship in? d. m.

By the *Mariner's Compass*, Long. of the I. *Barbadoes* is 58 04 W.

The Difference of Longitude is 275 Leagues, or ——— 13 45 E.

Subtract, gives the Longitude the Ship is in ——— 44 19 W.

Example 2. From the *Lizard* a Ship sails S. Westerly, 'till the Difference of Long. be 352 Leag. What Longitude is the Ship in? d. m.

By the *Mariner's Compass*, Longitude of the *Lizard* is 5 24 W

The Difference of Longitude is 352 Leagues ——— 17 36 W

Add, gives the Longitude the Ship is in ——— 23 00 W

Thus much for the Preparation to Sailing by this Chart, the Problems are next.

Sect,

Sect. III. *Containing Problems of Sailing by Mr. Wright's Chart, commonly call'd Mercator's-Sailing.*

IN the Working of these Problems, a Table of Meridional Parts is necessary ; accordingly out of Mr. *Wright's* Table, I have drawn one to every fifth Minute of Latitude, counting the Meridional Parts in Miles, or Minutes of the Equator : See Pages 304, 305, for their Use ; which Tables you will find placed before the Table of Logarithms, whose Use is to find the Meridional Difference of Latitude, between any two given Latitudes, and that is done by the next Problem.

Problem 1. *To find the Meridional Difference of Latitude, or the Difference of Latitude in Meridional Parts.*

The Rule is,

The Latitudes of $\left\{ \begin{array}{l} \text{one} \\ \text{a contrary} \end{array} \right\}$ Name, the $\left\{ \begin{array}{l} \text{Diff.} \\ \text{Sum} \end{array} \right\}$ of the Meridional Parts, (found in the Table of Meridional Parts) answering to the Degrees and Minutes of each Places Latitude, is the Meridional Difference of Latitude required.

Example 1. *Island Barbadoes, and St. Thome, an Island on the Coast of Gabon in Africa ; What is the Meridional Difference of Latitude ?*

				Minutes
Island	$\left\{ \begin{array}{l} \text{Barbadoes} \\ \text{St. Thome} \end{array} \right\}$	Lat.	$\left\{ \begin{array}{l} 13^{\text{d.}} 25^{\text{m.}} \text{ N.} \\ 00^{\text{d.}} 00^{\text{m.}} \end{array} \right\}$	$\left\{ \begin{array}{l} 812 \\ 000 \end{array} \right\}$
			Mer. Pts.	
Meridional Difference of Latitude				812

Example 2. *The Lizard and Island Barbadoes ; What is their Meridional Difference of Latitude ?*

				Min.
Lizard	$\left\{ \right\}$	Latitude	$\left\{ 50^{\text{d.}} 00^{\text{m.}} \right\}$	N. Merid. Parts $\left\{ \begin{array}{l} 3474 \\ 812 \end{array} \right\}$
I. Barbadoes			$\left\{ 13^{\text{d.}} 25^{\text{m.}} \right\}$	
Subtract, gives the Meridional Difference of Latitude				2662

Example

Example 3. Island Barbadoes, and Island St. Helena; *What is their Meridional Difference of Latitude?*

				Min.
Island	{ Barbadoes }	Lat. { 13d. 25m. N. }	Merid. Parts {	812
	{ St. Helen. }	{ 16d. 03m. S. }		976

Add, gives the Meridional Difference of Latitude ——— 1788

Problem 2. *The Latitude and Longitude of two Places given; to find the Course and Distance.*

Example. *What is the Course, and Distance from the Lizard to the Island Barbadoes?*

	d. m.		Min.		d. m.
Lizard	{ 50.00N }	Mer. Pts. {	3474	Lon. {	5.24 W
I. Barba.	{ 13.25N }		812		58.04 W

Diff. of Lat. ——— 36.35 S. Mer. Diff. Lat. 2662 Diff. Lon. 52.40 W
60 60

or 2195 Min.

or 3160 min.

This Rectangle Triangle ABC (*Plate 3. Fig. 5.*) is made by *Problem 13. of Practical Geometry*, after this manner.

1. From A representing the Place sailed from, lay the Meridional Difference of Latitude to B.

2. Draw BC perpendicular to AB, and thereon lay the Difference of Longitude, from B to C.

3. From A to C (representing the Place the Ship is bound to) draw a Line, which concludes the Triangle ABC, Right-angled at B, whose Angle BAC measured on the Scale of Chords or Rumbs, shews the Course, or Bearing of the two Places.

4. Take the Difference of Latitude, and lay it on the Meridian, from A to D, and draw a Line DE, parallel to BC, to cut AC in E, and it's done: For if AE be measured on the same Scale AD was taken from, it sheweth the Distance between the two Places.

But to resolve it by *Trigonometry*, there are two Rectangle Triangles

Triangles ABC, and ADE; in the former you must *Note*,

1. The Leg AB, is the Meridional Difference of Latitude.
2. The Leg BC, is the Difference of Longitude.
3. The Angle BAC, is the Course, or Bearing.
4. The Angle ACB, is the Complement of the Course.

Secondly, In the Rectangle Triangle ADE.

1. The Leg AD is the proper Difference of Latitude.
2. The Hypotenuse AE, is the Difference of the two Places.
3. The Leg DE, is the Departure from the Meridian.
4. The Angle DAE, is the Course, or Bearing.
5. The Angle AED, is the Complement of the Course.

These things being premised, the Proportions according to *Axiom 1. Note 2d.* of Plain Right Angle Triangles, is as followeth :

1. For the Course, the Proportion by *Axiom 1, Note 2d.* is this :

If the Leg AB is made Radius, then the Leg BC is the Tangent of the Angle BAC, and therefore it is,

As the Meridional Difference of Latitude, is to the Radius ; so is the Difference of Longitude, to the Tangent of the Course ; but more briefly thus :

Merid. Diff. Lat. .. Diff. Long. :: Radius .. T. of the Course.

2662 Minutes .. 3160 Min. :: T. 45d, .. T. 49d. 53m.

Which being turned into Points of the Compass, makes the Course to be SW half W. nearly.

2. To find the Distance, the Proportion by *Axiom 1. Note 1st.* is this :

Making the Hypotenuse AE Radius, the Leg AD is the Sine of the Angle AED, or the Sine Complement of the Course, and therefore it is,

As the Sine Complement of the Course, is to the proper Difference of Latitude ; so is the Radius, to the Distance in the Rumb. Or more briefly thus ;

S. c. Course .. Diff. Lat. :: Radius .. Distance required.

S. 40d. 07m. .. 2195 Min. :: S. 90d, .. 3407 Minutes.

Note, The Meridional Difference of Latitude may be found by the *Gunter's Scale*, thus ;

Extend the Compasses from the Latitude of 50d. 00m. (on the Meridional-line) to the Latitude 13d. 25m. on the same Line ;

Line; that Extent measured on the Line of equal Parts will be $44\frac{1}{8}$ d. or 2664 Minutes, the Meridional Difference of Latitude, which is but 2 Minutes more than by the Table.

Problem 3. *Both Latitudes and Course given; to find the Distance, and Difference of Longitude.*

Examp. A Ship sails from the Lizard, and makes her Course (when Variation, Lee-way, &c. are allowed for) to be S. 39d. W. or SW. by S. $\frac{1}{4}$ W. and then by Observation, is in Latitude 45d. 31m. N. I demand the Distance run, and the Longitude she is in?

	d.	m.	Minutes
Lizard } Latitude	50	00	N
Observed } Latitude	45	31	N
Meridional Parts			
			3474
			3074
Difference of Lat.	4	29	
		60	
Mer. Diff. Lat.	— 400		

Or ———— 269 Minutes.

To delineate this, or any of the Seven next Problems, by the Plain Scale, as also their Resolutions by Plain Trigonometry, the Directions and Notes in the foregoing Problem may be sufficient Instructions, and therefore they are omitted 'till I come to Problem 10.

1. To find the Distance, the Proportion (as in Plain Sailing) is this:

S. c. Course .. Diff. Lat., :: Radius .. Distance

S. 51d. 00m. .. 269 Min. :: S. 90d. .. 346 Minutes.

2. To find the *Difference of Longitude*, the Proportion is this;

Radius .. T. Course :: Merid. Diff. Lat. .. Diff. of Long.

T. 45d. .. T. 39d. :: 400 Minutes .. 325 Min. or $5^{\circ} 25'$.

Or thus; the Extent on the Meridional Line (on the Gunter) from Latitude 50d. 00m. to Latitude 45d. 31m. measured on the Line of Equal Parts, is 6d. $\frac{1}{8}$. the Meridional Difference of Latitude; and then you may say,

T. 45d. .. T. 39d. :: 6d. $\frac{1}{8}$. .. 5d. $\frac{1}{8}$. or 5d. 24m. the Difference of Longitude, differing but one Minute from what is found above.

3. Then to find the Longitude the Ship is in, 'tis thus,

Longitude sailed from ————— 5d. 24m West.

Difference of Longitude 325 Minutes, or — 5d. 25m West.

Longitude the Ship is in ————— 10d. 49m West.

Prob.

Problem 4. Both Latitude and Distance given; to find the Course, and Difference of Longitude.

Example. If a Ship runneth 300 Minutes North Westward, from a Port in Lat. 37d. N. and Longitude 10d. 25m. W. until she be in Latitude 41 Degrees North: I demand the Course steered, and what Longitude she is?

Sailed from	}	Latitude	{	37d. North	}	Merid. Parts	{	2393
Ship is in				41d. North				2702
Difference of Latitude				4 North,	Merid. Diff. Latit.			309
								60

Or 240 Minutes.

1. To find the Course, the Proportion (as in Case the 4th of Plain-Sailing) is thus;

Distance .. Radius :: Diff. Lat. .. S. c. Course.

300 Min. .. S. 90d. :: 240 Min. .. S. 53d. 08m. Which
subtract from ————— 90d. 00m.

Remainder is the Course ————— 36d. 52m. North
Westerly $3\frac{1}{4}$ Points of the Compass, which makes the Course to be NW by N. $\frac{1}{4}$ W. nearest.

2. To find the Diff. of Longitude, the Proportion is thus;
Radius .. T. Course :: Merid. Diff. Lat. .. Difference Long.
T. 45d. .. T. 36d. 52m. :: 309 Minutes .. 232 Min. or 3d. 52m.

Or thus, the Extent (on the *Meridional Line on the Gunter*) from Latitude 37d. to Latitude 41d. measured on *Equal Parts*, is 5d. 10m. Meridional Difference of Latitude. Then say,
T. 45d. .. T. 36d. 52m. :: 5d. $1\frac{1}{2}$.. 3d. 88 Parts of 100, or 3d. 52m. the Difference of Longitude as before.

Longitude sailed from ————— 10d. 25m. West.

Difference of Longitude, is 232 Minutes or 3d. 52m. West.

Longitude the Ship is in ————— 14d. 17m. West.

Problem 5. Both Latitudes and Departure from the Meridian given; to find the Course, Distance and Difference of Longitude.

Example. A Ship in Latitude 50d. 10m. North, and Longitude 5d. 24m. West, sails South Westward, 'till her Departure is 789 Minutes, and by Observation is in Latitude 39d. 20m. North: I demand the Course steered, Distance sailed by the Log, and what Longitude the Ship is in?

The

1. The Proportion for the Course and Distance, are the same as in *Chapter 3. Section 3. Problem 6. of Plain Sailing*, in *Page 63.* to which I refer you, and here omit them.

2. To find the Difference of Longitude, the Proportion is;

Lat. $\left\{ \begin{array}{l} \text{Departed } 50\text{d. } 10\text{m. N.} \\ \text{Ship is in } 39\text{d. } 20\text{m. N.} \end{array} \right\}$ Merid. Pts. $\left\{ \begin{array}{l} 2490 \\ 2571 \end{array} \right\}$ Min.

Differ. of Latit. $10\text{d. } 50\text{m.}$ Mer. Diff. Lat. 919 Min.

Or, 60

Differ. Latit. 650 Minutes. Then you may say,

As Diff. Lat. .. Departure :: Merid. Diff. Lat. .. Diff. Longit.

As 650 min. .. 789 Min. :: 919 Minutes .. 1116m. or $18\text{d. } 36\text{m.}$

Or thus; The Extent (on the Meridional Line on the *Gunter*) from Latitude $50\text{d. } 10\text{m.}$ to Latitude $39\text{d. } 20\text{m.}$ (measured on the Line of Equal Parts) is $15\text{d. } 3$ Tenths, the Meridional Difference of Latitude. And then say,

As 650 Minutes .. 789 Min. :: $15\text{d. } 3$ Tenths .. $18\text{d. } 6$ Tenths or $18\text{d. } 36\text{m.}$ the Difference of Longitude, as before.

3. Then, to find the Longitude the Ship is in, 'tis thus;

Longitude failed from _____ $5\text{d. } 24\text{m.}$ West.

Difference of Longitude 1116 Min. or _____ $18\text{d. } 36\text{m.}$ West.

Longitude the Ship is in _____ $24\text{d. } 00\text{m.}$ West.

Problem 6. One Latitude, Course, and Distance given; to find the Difference of Latitude, and Difference of Longitude.

Example. A Ship in Latitude $42\text{d. } 30\text{m.}$ North, and Longitude $18\text{d. } 31\text{m.}$ West, sails S. E. by S. 591 Minutes, or 197 Leagues; I demand the Latitude, and Longitude the Ship is in?

1. For the Difference of Latitude, the Proportion (by the *1st Case of Plain Sailing*, in *Page 60*) is thus:

As Radius .. Distance :: S. c. Course .. Difference of Latitude.

As S. 8 Points .. 591 Min. :: S. 5 Pts. .. 491 Min. or $8\text{d. } 11\text{m.}$

Latitude failed from _____ $42\text{d. } 30\text{m.}$ N. Merid. Parts 2822m.

Diff. Lat. 491 Min. or _____ $8\text{d. } 11\text{m.}$ S.

Latitude the Ship is in _____ $34\text{d. } 19\text{m.}$ N. Merid. Parts 2195m.

Subtract, giveth the Meridional Difference of Latitude 627m.

Or thus; The Extent (on the Meridional Line on the *Gunter*) from Latitude $42\text{d. } 30\text{m.}$ to Latitude $34\text{d. } 19\text{m.}$ measured

on the Line of Equal Parts is 10d. $\frac{1}{8}$ or 10d. 30m. the Meridional Difference of Latitude.

2. To find the Difference of Longitude, the Proportion is,
As Radius .. T. Course :: Merid. Diff. Lat. .. Differ. Longitude.

As T. 4 Pts. .. T. 3 Points :: 627 Minutes .. 420m. or 7d. 00m.

Or thus ;

As T. 4 Points .. T. 3 Pts. :: 10d. $\frac{1}{8}$.. 7d. Diff. Long. as before.

Longitude fail'd from ————— 18d. 31m. West.

Diff. Long. 420 Minutes, or ————— 07d. 00m. East.

Longitude the Ship is in ————— 11d. 31m. West.

Problem 7. *One Latitude, Course, and Departure given, to find the Distance, Difference of Latitude, and Difference of Longitude.*

Example. A Ship sails E S E. from a certain Port in Latitude 50d. 10m. South, and Longitude 10d. 16m. East, until the Departure from the Meridian be 957 Minutes : I demand her Distance fail'd, the Latitude and Longitude she is in ?

1. The Distance is 1035 } Min. by Chapter 2. Section 3.

2. The Diff. of Lat. 396 }

Problem 3. of *Plain Sailing*, in Page 61. Then the Latitude the Ship is in, and the Meridional Difference of Latitude, is found thus ;

Latitude failed from 50d. 10m. South, Merid. Parts— 3490

Diff. Latitude 396m. or 6d. 46m. S.

Latitude Ship is in— 56d. 46m. S. Meridional Parts— 4157

Subtract, giveth the Meridional Difference of Latitude — 667

3. To find the Difference of Longitude, the Proportion is,
As Diff. Lat. .. Departure :: Merid. Diff. Lat. .. Diff. of Long.

As 396 Min. .. 957 Min. :: 667 Min. .. 1615m. or 26d. 55m.

Or thus ; the Extent (on the Meridional Line on the Gunter) from Latitude 50d. 10m. to Latitude 56d. 46m. measured on the Line of Equal Parts ; is 11d. $\frac{1}{8}$ the Merid. Diff. of Lat.

Then say,

As 396 Min. .. 957 Min. :: 11d. $\frac{1}{8}$.. 27d. the Diff. Lon.

Then to find the Longitude the Ship is in, it's thus ;

Longitude failed from ————— 10d. 16m. East.

Difference of Longitude 1615 Min. or — 26d. 55m. East.

Longitude the Ship is in ————— 37d. 11m. East.

Prob.

Problem 8 *One Latitude, Distance sail'd, and Departure from the Meridian given, to find the Course, Difference of Latitude, and Difference of Longitude.*

Example. A Ship in Latitude 49d. 30m. North, and Longitude 14d. 40m. West, sails South Eastward 645 Minutes, until the Departure from the Meridian be 500 Minutes: I demand the Course steered, the Latitude, and Longitude the Ship is in?

1. The Course is S. 50d. 50m. E. or $SE \frac{1}{2} E.$ } by Chap 3.
 2. The Diff. of Lat. 407min. or 6d. 47 min. }

Section 3. *Problem 5. of Plain Sailing, in Pages 62 and 63.*
 Then the Latitude the Ship is in, and the Meridional Difference of Latitude, is found thus;

Latitude sail'd from — 49d. 30m. N. Merid. Parts 3428
 Diff. Lat. 407 min. or — 6d. 47m. S.

Latitude the Ship is in — 42d. 43m. N. Merid. Parts 2849
 Meridional Difference of Latitude 588

3. To find the Difference of Longitude, the Proportion is;
 As Diff. Lat. .. Depart. :: Merid. Diff. Lat. .. Diff. of Long.
 As 407 min. .. 500min. :: 588 min. .. 722 min. or 12d. 2m.

Or thus; the Extent (on the Meridional Line on the Gunter) from Latitude 49d. 30m. to Latitude 42d. 43m, (measured on equal Parts) is 9d. $1\frac{1}{2}$, the Meridional Difference of Latitude: Then say,

As 407 min. .. 500 min. :: 9d. $1\frac{1}{2}$.. 12d. the Diff. Long.

Then, to find the Longitude the Ship is in, 'tis thus;

Longitude sail'd from ————— 14d. 40m. West.

Diff. Longit. 722 Minutes, or ————— 12d. 02m. East.

Longitude the Ship is in ————— 2d. 38m. West.

Problem 9. *One Latitude, Course, and Difference of Longitude given; to find the Distance, and Difference of Latitude.*

Example. A Ship sails SW. by W. from the Lizard, until she be in Longitude 57d. 26m. West. I demand the Latitude the Ship is in, and her Distance sail'd?

Longitude sail'd from ————— 5d. 24m. West.

Longitude the Ship is in ————— 57d. 26m. West.

Subtract, and Remainder is the Diff. Long. 52d. 02m.

60

Or 3122 Minutes.

1. For the Mer. Difference of Latitude, the Proportion may be thus;

As T. Courfe .. Radius :: Differ. Long. .. Mer. Diff. of Lat.

As T. 5 Pts. .. T. 4 Pts. :: 3122 Minutes .. 2085 Minutes.

Latitude failed from 50d. its Merid. Parts — 3474 subtract

giveth the Mer. Pts. for the Lat. the Ship is in 1389 which seek in the Table of Meridional Parts; and against it you will find 22d. 33m. the Latitude the Ship is in North.

Or thus, on the *Gunter*; take the Meridional Difference of Latitude, being 2085 Minutes, or 34d. 45m. from the Line of equal Parts, and set it from the Latitude departed from, viz. 50d. 00m. on the Meridional Line decreasing (because 'tis North Latitude, and sailing Southerly) and it reacheth (in the same Line) to 22d. 30m. the Latitude the Ship is in, very near to the Latitude found above by the Table of Meridional Parts, differing from it but 3 Minutes.

Then having both Latitudes known, the Difference of Latitude is found (by subtracting the less from the greater) to be 27d. 27m. or 1647 Minutes, or 549 Leagues.

2. Find the Distance sail'd by Chapter 3. Section 3. Problem or Case 2. of Plain Sailing, in Page 61.

Problem 10. Two Places in one Parallel, or Latitude, their Difference of Longitude given; to find their Distance.

Example. I demand the Distance between the *Island* and *Penguin Island* on *Newfoundland*?

Penguin Island } Longit. is { 50° West.
Lizard } 46° 46m. West.

Subtract, and Remainder is Diff. Long. — 4° 14m. West.
Or, 60

Difference of Long. 2866 Minutes.

These Places are both (supposed to lie) in Latitude 50d. 00m. North, whose Complement is 40d. 00m.

To delineate this Problem by the Plain Scale.

1. Draw the prick'd Arch BC, with the Sine of 90 Degrees, one Foot being on the Center A.

2. Lay the Difference of Longitude on that Arch, from B to C, and draw the Lines AB, AC, and BC.

3. With

3. With the Sine Complement of the Latitude, and one Foot in A, draw the Arch DE; that is, take the Complement of the Latitude from the Line of Sines, and with one Foot on A, draw the prick'd Arch DE, to cut AB in D, and AC in E.

4. Draw a Line from D to E, and 'tis done; for DE being measured on the same Scale BC was taken from, will shew the Distance required.



The Explanation of the Scheme.

1. }		A	represents the	North Pole of the Earth.
2. }	The Point	D		Lizard
3. }		E		Penguin Isle
4. }	The Arch	BC		} in the Latitude of 50d. 00m.
5. }		DE		
6. }		ADB		Equator.
7. }	The Line	AEC		Parallel of 50d. N. Lat.
8. }		BC		Meridian of } The Lizard.
9. }		DE		Meridian of } Penguin Island.
				Diff. Long. between the 2 Places.
				Diff. between them in that Parallel

Then to find their Distance; the Proportion, by the 4th. Proposition of the sixth Book of Euclid, is,

As AB, is to BC; so is AD, to DE. And alternately,

As AB, is to AD; so is BC, to DE. That is,

As Radius, is to the Sine Complement of the Latitude; so is the Difference of Longitude, to their Distance in that Parallel of Latitude. In short thus:

As Radius .. S. c. Latitude :: Diff. Long. .. Distance.

As S. 90d. .. S. 40d. 00m. :: 2866 Min. .. 1842 Min.

Or thus ; By the *Plain Scale*.

Take the Latitude of 50d. 00m. from the Scale of Chords, and measure it from 60 on the Scale of Miles of Longitude, marked (ML) and it sheweth Minutes 38.6 Tenths make a Degree of Longitude in that Latitude. Then say,

As 1 Deg. .. Min. 38.6 :: Diff. Long. 47d. 18 $\frac{1}{2}$.. 1842 Minutes the Distance as before.

Problem II. *Two Places in one Latitude, their Distance given ; to find their Difference of Longitude.*

Example. If a Ship sails West 390 Minutes from the Lizard ; What Longitude is she in ?

To delineate this *Problem* by the *Plain Scale*.

1. Take 90 Degrees from the Line of Sines, and with one Foot on A, draw the prick'd Arch BC.

2. from the Line of Sines, take the Complement of the given Latitude, and setting one Foot on A, draw the prick'd Arch DE.

3. Then from any Scale of equal Parts, take the Distance (*sail'd*) and lay it on the last Arch, from D to E.

4. From A draw Lines through D and E, to cut the Arch BC, in B, and in C.

5. Then draw a Line from B to C, and 'tis done ; for BC being measured on the same Scale DE was take from, will shew the Difference of Longitude required.

The Proportion (by the 4th Proposition of the 6th Book of Euclid) for the Difference of Longitude, is,

As S.c. Latitude .. Radius :: Distance .. Difference of Long.

As S. 40d. 00m. .. S. 90d. :: 390min. .. 607min. or 10d. 07m.

Or thus ; By the *Plain Scale*.

The Latitude 50d. 00m. taken (from the Chords) and measured on the Scale of Miles of Longitude, sheweth the Minutes 38.6 Tenths make a Degree of Longitude in that Latitude ;

As 38.6 Tenths .. 1d. :: 390m. .. 10d. 1 $\frac{1}{2}$ or 10d. 06m. Diff. Long. differing but one Minute from that found before.

Longitude of the Lizard ————— 05d. 24m. West.

Difference of Longitude 607 min. or — 10d. 07m. West.

Add, gives the Longitude the Ship is in — 15d. 31m. West.

Prob.

To find the Latitude (by the foresaid Proposition of *Euclid*) the Proportion is thus;

As Diff. Long. .. Distance :: Radius .. S. c. Latit. required.

As 2842 Min. .. 1823 min. :: S. 90d. .. S. 40d. 10m.

Which subtracted from ————— 90d. 00m.

The Remainder is the Parallel of Latitude — 49d. 50m. North.

Or thus; by the *Plain-Scale*.

As 2842 min. .. 1833 min. :: 60 min. .. min. 38.7 Tenths, making one Degree of Longitude, in the Latitude required.

Then from the Scale of Miles of Longitude (marked ML) take Min. 38.7 Tenths, measure it on the Scale of Chords, and it sheweth the Latitude to be 49d. 50m. as before.

Section IV. *Problems of Sailing by the Middle Latitude; or a Proportion drawn from the Middle Latitude, nearly agreeing with Mercator's-Sailing.*

IN these Problems, there is no Use made of the Table of Meridional Parts, and all its Proportions may be wrought both by the Logarithms, and *Gunter's-Scale*.

Problem I. *The Latitude, and Longitude of two Places given; to find their Course and Distance.*

Example. What is the Course and Distance from the *Lizard* to the Island *Barbadoes*?

	d. m.		d. m.		d. m.
<i>Lizard</i> }	50 00 N.	—	50 00 }	5 24 W.	
<i>Barbadoes</i> }	13 25 N.	—	13 25 }	58 04 W.	

Difference Latitude 36 35 S. sum is 63 25 Diff. Long. 52 40 W.
60 Mid. Lat. 31 42 60

Minutes 2195 subtr. it from 90 00 or 3160 min.

Compl. Mid. Lat. 58 18

To delineate this Problem by the *Plain-Scale*, *Plate 3. Fig. 6.*

1. Make AD upon the Meridian equal to the Difference of Latitude.

2. Draw the prick'd Arch IK with the Sine of 90 Degrees (one Foot being on A) to cut the Meridian AD in I.

3. With the Sine Complement of the Middle Latitude, and one Foot on A, draw the prick'd Arch GH, to cut the Meridian in G,

+

4. On

4. On the last Arch, lay half the Difference of Latitude, from G to H.

5. By A and H, draw a Line, to cut the first Arch (made with the Sine of 90 Degree:) in K.

6. Lay IK twice on the Meridian, from A to B.

7. On B erect a Perpendicular, and thereon lay the Difference of Longitude, from B to C.

8. Draw a Line from A to C; and from D, draw DE parallel to BC, to cut AC in E, and it's done. *Plate 3. Fig. 6.*

Then is the Leg AD, the Difference of Latitude.

The Leg BC, the Difference of Longitude.

The Hypotenuse AE, the Distance of the two Places.

The Leg DE, the Departure, according to the *Plain-Chart*.

The Angle DAE, or BAC, the Angle of the Course or Bearing.

The Angle AED, the Complement of the Course.

1. To find the Course, or Bearing, the Proportion is;

As the Difference of Latitude, is to the Difference of Longitude; so is the Sine Complement of the Middle Latitude, to the Tangent of the Course, Or more briefly thus;

As Diff. Lat. .. Diff. Long. :: S. c. Mid. Lat. .. T. Course.

As 219.5 min. .. 3160 min. :: S. 58d. 18m. .. T. 50d. 45m.

By *Gunter*. The Extent from 2195 Minutes to 3160 Minutes on the *Line of Numbers*, being laid (increasing) from Sine 38d. 18m. reacheth beyond the Sine of 90d. wherefore lay that Extent from the Sine of 90 Degrees towards the Left-hand, and stay one Foot there; then bring in the other Foot to the Sine Complement of the Middle Latitude 58d. 18m. this last Extent of the Compasses, lay from Tangent 45 Degrees, and it sheweth on Tangents 50d. 45m. the Course South westerly, or SW half W. which is the Course from the *Lizard* to the Island *Barbadoes*.

Or thus; By two Proportions to find the Course.

First, As the Radius, is to the Sine Complement of the Middle Latitude; so is the Difference of Longitude, to the Departure from the Meridian, or Meridional Distance.

More briefly thus;

As Radius .. S. c. Middle Lat. :: Diff. Long. .. Departure.

As S. 90d. .. S. 58d. 18 min. :: 3160 Min. .. 2685 min.

Secondly, As the Difference of Latitude, is to the Departure from the Meridian; so is the Radius, to the Tangent of the Course.

Or

Or more briefly thus ;

As Diff Lat .. Departure :: Radius .. T. Course,

As 2195 min. .. 2685 min. :: T. 45d. .. T. 50d. 45m. as before.

2. To find the Distance, the Proportion is,

As S. c. Courie .. Diff. Lat. :: Radius .. Distance required.

As S. 39d. 15m. .. 2195 min. :: S. 90d. .. 3467 Minutes.

Problem 2. Both Latitudes and Course given ; to find the Distance, and Difference of Longitude.

Example. Suppose a Ship sails from the *Lizard*, and makes (when Variation, Lee-way, &c. allowed for) her Course South 39d. West, or S W by S. $\frac{1}{2}$ W and then, by Observation, is in Latitude 45d. 31m. North ; what's her Distance run, and Longitude she is in ?

<i>Lizard</i>	} Latitude	{ 50d. 00m. North	_____	50 00
Observed		{ 45d. 31m. North	_____	45 31
Difference of Latitude		4d. 29m.	Sum both Latitudes	95 31
		60	The half is Mid. Lat.	47 45

Or, Minutes 269 Which subtract from 90 00

The Remainder is Compl. of the Middle Latitude _____ 42 15

To delineate this, or any of the following *Problems*, by the *Plain Scale*, the Instructions in the foregoing are sufficient to inform the diligent Learner.

1. The Distance is 346 Minutes by *Chapter 6. Section 3. Problem 3d. of Mercator's-Sailing*, in Page 95.

2. To find the Difference of Longitude, the Proportion is,

As the Sine Complement of the Middle Latitude, is to the Tangent of the Course : so is the Difference of Latitude, to the Difference of Longitude. Or thus ;

As S. c. Mid. Lat. .. T. Course :: Diff. Lat. .. Diff. of Long.

As S. 42d. 15m. .. T. 39d. :: 269 min. .. 324 min.

To work this, or any such like Propoportion, by *Gunter's Scale*, the General Rule of extending from the First Term to the Second, &c. will not serve, 'till the First and Second Terms are reduced to one Line, or Scale, and that by this Rule following.

A General Rule to reduce the Second Term Tangent, to the First Term Sine.

Extend the Compasses from Tangent 45d. to the Tangent of the Second Term ; lay that Extent on the Line of Sines, from 90d. if the Second Term be less than 45d. but if more, from the First

First Term towards the left Hand; and where the Foot resteth, I call the Second Term reduced to the First, and is to be counted instead of the Second Term; as for *Example*.

To work the 'foresaid Proportion, to find the Difference of Longitude.

1. The Extent from Tangent 45d. to Tangent 39d. laid from Sine 90d. reacheth to 54d. 05m. the Second Term reduced to the First Term.

2. The Extent from 54d. 05m. (the Second Term reduced) to Sine 42d. 15m. the First Term in the Proportion; laid on the Line of Numbers from 269 Minutes, the Third Term, will reach to 324 Minutes, the Fourth Term, the Difference of Longitude required.

Or thus; By two Operations to find the Difference of Longitude.

First; As the Sine Complement of the Course, is to the Difference of Latitude: so is the Sine of the Course, to the Departure from the Meridian, or Meridian Distance. Or thus;

As S. c. Course .. Diff. Lat. :: S. Course .. Departure.

As S. 51 deg. .. 269 min. :: S. 39 deg. .. 218 min.

Secondly; As the Sine Complement of the Middle Latitude, is to Radius: so is the Departure from the Meridian, to the Difference of Longitude. Briefly thus;

As S. c. Middle Lat. .. Radius :: Departure .. Diff. Long.

As S. 42d. 15m. .. S. 90d. :: 218 min. .. 324m. as before

Then to find the Longitude the Ship is in, 'tis thus,

Lizard Longitude is ————— 05d. 24m. West.

Diff. Longitude 324 Minutes, or ————— 05d. 24m. West.

Longitude the Ship is in ————— 10d. 48m. West.

Problem 3. Both Latitudes, and Distance given; to find the Course and Difference of Longitude.

Example. If a Ship runneth 300 Minutes North Westerly, from a Port in 37 deg. North Latitude, and Longitude 10d. 25m. W. until she be in Lat. 41 deg. North: What is her Course, and Longitude she is in?

Sailed from { Latitude } 37d. North ————— 37d.
Ship is in— { 41d. North ————— 41d.

Difference of Latitude ————— 4d. N. Sum of both Latit. 78d.

60

Middle Latit. 39d.

Or, Minutes 240

Subtract from 90d.

Complement of the Middle Latitude 51d.

1. The

1. The Course is North 36 deg. 52 min. West, or NW. by N. $\frac{1}{2}$ West nearest; found by *Chapter 4. Section 3. Problem 4. of Mercator's Sailing*, in Page 96.

2. To find the Differ. of Longit. the Proportion is thus;

As S. c. Mid. Lat. .. T. Course :: Differ. Lat. .. Diff. Long.

As S. 51 Degrees .. T. 36d. 52m. :: 240 min. .. 232 min.

By *Gunter's Scale*. The Extent from Tangent 45d. to Tangent 36d. 52m. will reach from Sine 90d. to Sine 48d. 30m. the Second Term reduced to the First. Then the Extent from this last (Sine 48d. 30m.) to Sine 51d. (the First Term in the abovesaid Proportion) will reach on the Line of Numbers from the Difference of Latitude 240 Minutes, to 232 Minutes, or 3d. 52m. the Difference of Longitude.

Or thus; By two Proportions (after the Course is found, as before) to find the Difference of Longitude, say;

1. As the Radius, is to the Distance sailed; so is the Sine of the Course, to the Departure from the Meridian:

Which briefly is thus;

As Radius .. Distance :: S. Course .. Departure.

As S. 90d. .. 300 min. :: S. 36d. 52m. .. 180 Minutes

2. As the Sine Complement of Middle Latitude, is to Radius; so is the Departure from the Meridian, to the Difference of Longitude. Briefly is thus;

As S. c. Mid. Lat. .. Radius :: Departure .. Diff. Long.

As S. 51 Degrees .. S. 90d. :: 180 Min. .. 232 Min.

Or it may be found by this Proportion, when the Distance is given.

S. c. Mid. Lat. .. Distance :: S. Course .. Diff. Longit.

S. 51 Degrees .. 300 Min. :: S. 36d. 52m. .. 232m. as above.

Then to find the Longitude the Ship is in, 'tis thus;

Longitude the Ship sailed from ——— 1cd. 35m. West.

Diff. Longitude 232 Minutes, or ——— 3d. 52m. West.

Longitude the Ship is in ——— 14d. 27m. West.

Problem 4. Both Latitudes, and Departure from the Meridian given; to find the Course, Distance, and Difference of Longitude.

Example. A Ship in Latitude 50d. 10m. North, and Longitude 5d. 24m. West; sails South Westerly, 'till the Departure be 789 Minutes, and she be in Lat. 39d. 20m. North; I demand the Course, Distance, and Longitude the Ship is in?

La-

Latitude $\left\{ \begin{array}{l} \text{Sail'd from } 50^{\circ} 10' \text{ North} \\ \text{Ship is in } 39^{\circ} 20' \text{ North} \end{array} \right. \begin{array}{l} \text{--- } 50^{\circ} 10' \\ \text{--- } 39^{\circ} 20' \end{array}$

Difference of Latitude-- $10^{\circ} 50'$. Sum of both Lat. $89^{\circ} 30'$.

Or Minutes 650 The $\frac{1}{2}$ is Mid. Lat. $44^{\circ} 45'$.
Which subtract from $90^{\circ} 00'$.

The Remainder is Comp. of the Middle Latitude $45^{\circ} 15'$.

1. The Course is S. $50^{\circ} 30'$ W. } by Chapter 4 Section
2. Distance 1022 Minutes. } 3. Problem 5. of Mercator's Sailing, in Page 97.

3. To find the Difference of Longitude, the Proportion is;
As S. c. Mid. Lat. .. T. Course :: Diff. Lat. .. Diff. Long.
As S. $45^{\circ} 15'$.. T. $50^{\circ} 30'$:: 650 Min. .. 1112 Min.

For the Extent from Tangent 45° to the Tangent $50^{\circ} 30'$ laid (on the Line of Sines) from $45^{\circ} 15'$ reacheth to Sine $35^{\circ} 50'$ the Second Term reduced to the First. Then the Extent from this last (Sine $35^{\circ} 50'$) to S. 90° (instead of Sine $45^{\circ} 15'$ the First Term in the above Proportion, always when the Course is more than 45° and that) laid on the Line of Numbers, from Diff. Lat. 650 Minutes, will reach to 1112 Minutes, the Difference of Longitude required.

Or thus; the Difference of Longitude may be found without finding the Course, saying;

As the Sine Complement of the Middle Latitude, is to the Radius: so is the Departure from the Meridian, to the Difference of Longitude. That is,

As S. c. Mid. Lat. .. Radius :: Departure .. Differ. Longit.
As S. $45^{\circ} 15'$.. S. 90° :: 780 Min. .. 1112 m. as before.

Then the Longitude the Ship is in, may be found, as in Problem 5. of Mercator's Sailing, in Page 97, that being the same Question with this.

And in like manner all the remaining Questions in Mercator, may be wrought by the Sine Complement of the Middle Latitude, which I leave to the Learner's Practice. And thus much may suffice for the Second Kind of Sailing, or Second Part of Navigation, and the Application of Plain Trigonometry. Spheric Trigonometry is next.

Chapter V. *Containing the Doctrine of Spheric Triangles, Rectangular and Oblique, both Geometric, Arithmetic, and Instrumental.*

BEfore I enter on Spheric Trigonometry, as to the framing, and working of Proportions therein, it will be necessary you should understand how to make a Spheric Triangle, and to measure any of its Parts: In Order thereunto I have contrived the following Problems, which I call Spheric Geometry.

Section I. Spheric Geometry explained by Definitions, and Problems.

Definition 1. *Spheric Geometry*, is that by which the Circles of the Sphere are described, drawn, or projected on a Plane, or flat Superficies.

2. A *Sphere* or *Globe*, is a round Body, made by the moving of a Semi-circle about its own Diameter, 'till the Motion end where it began.

3. The *Projection of the Sphere*, is either *Orthographic*, *Stereographic*, or *Gnomonic*.

4. *Orthographic*, is the drawing the Superficies of the Sphere on a Plane, which cutteth the Sphere in the middle, with respect to the Eye being placed perpendicular to it, and at an infinite Distance therefrom: This Projection maketh Use only of a Line of Chords, and of Sines.

5. *Stereographic*, sheweth how to describe the Sphere's Superficies on a Plane, which cutteth it in the middle, with respect to the Eye being placed in the Sphere's Superficies, perpendicular to the Center of the said Plane.

6. *Gnomonic Projection of the Sphere*, is drawing the Superficies on a Plane touching it, with respect to the Eye being placed in the Sphere's Center.

These two last make use of the Lines of Chords, Tangents, and Secants.

7. All Circles of the Sphere, are either Great Circles, which cut it in two equal Parts; or Lesser Circles, which cut it in two unequal Parts.

8. This

Example. *An Angle EBF equal to 34d. 30m. (whose Angular Punct B may be at the Primitive Circle) is required to be made?*

Plate 3. Fig. 7.

1. Describe the primitive Circle BCDE, as before directed.
2. Lay a Scale on A (the primitive Circle's Center) and cut the primitive Circle in B, and D.
3. With the Secant of the given Angle 34d. 30m. and one Foot in B, describe an Arch Y.
4. With the same, and Foot on D, cross the former Arch Y, in Y; the Center of the Oblique Circle BFD, which will conclude the Angle EBF equal to EDF, required to be made.

Note; When the given Angle is Obtuse, take its Supplement to 180 Degrees, and with the Remainder make the Angle as above directed, and 'tis done.

Problem 3. *To draw a great Circle through any given Punct, so that it shall make at the Primitive Circle any given Angle.*

The Rule. 1. With the Tangent of the given Angle, and one Foot on the Center of the Primitive Circle, make an Arch.

2. With the Secant of the same, and one Foot in the given Punct, cut the former Arch, which Point of Intersection, is the Center of the Circle required to be drawn.

Example. Plate 3. Fig. 7.

BCDE the Primitive Circle	} given
A the Center thereof	
F the Punct	

Through F, to draw an Oblique Circle, that it may make an Angle at the Primitive Circle, equal to 34d. 30m. is required?

Note; The given Point must be so far from the Center of the Primitive Circle, that the Tangent from the Center, and the Secant (of the same) from the given Punct, may intersect, or cut each other; otherwise 'tis impossible.

1. With the Tangent of 34d. 30m. and one Foot in A, make an Arch Y.

2. Then with the Secant of the same, and one Foot in F, cut the Arch Y, in Y, the Center of the Oblique Circle BFD, required to be drawn; and if B, and D, are diametrically opposite, 'tis done true, otherwise not.

Problem 4. *To draw a Great Circle, through any two Puncts given; either both within the Primitive Circle, or one within, and the other without.*

The Rule. 1. Draw a Line from the Primitive Circle's Center, thro' one (always the remotest) of the two Puncts, to cut the Primitive Circle, and produce it at Pleasure.

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2. From

Chapter V. *Containing the Doctrine of Spheric Triangles, Rectangular and Oblique, both Geometric, Arithmetic, and Instrumental.*

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4. *Orthographic*, is the drawing the Superficies of the Sphere on a Plane, which cutteth the Sphere in the middle, with respect to the Eye being placed perpendicular to it, and at an infinite Distance therefrom: This Projection maketh Use only of a Line of Chords, and of Sines.

5. *Stereographic*, sheweth how to describe the Sphere's Superficies on a Plane, which cutteth it in the middle, with respect to the Eye being placed in the Sphere's Superficies, perpendicular to the Center of the said Plane.

6. *Gnomonic Projection of the Sphere*, is drawing the Superficies on a Plane touching it, with respect to the Eye being placed in the Sphere's Center.

These two last make use of the Lines of Chords, Tangents, and Secants.

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 Plate 3. Fig. 7.

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2. Lay a Scale on A (the primitive Circle's Center) and cut the primitive Circle in B, and D.
3. With the Secant of the given Angle 34d. 30m. and one Foot in B, describe an Arch Y.
4. With the same, and Foot on D, cross the former Arch Y, in Y; the Center of the Oblique Circle BFD, which will conclude the Angle EBF equal to EDF, required to be made.

Note; When the given Angle is Obtuse, take its Supplement to 180 Degrees, and with the Remainder make the Angle as above directed, and 'tis done.

Problem 3. *To draw a great Circle through any given Punct, so that it shall make at the Primitive Circle any given Angle.*

The Rule. 1. With the Tangent of the given Angle, and one Foot on the Center of the Primitive Circle, make an Arch.

2. With the Secant of the same, and one Foot in the given Punct, cut the former Arch, which Point of Intersection, is the Center of the Circle required to be drawn.

Example. Plate 3. Fig. 7.

BCDE the Primitive Circle	} given;
A the Center thereof —	
F the Punct —	

Through F, to draw an Oblique Circle, that it may make an Angle at the Primitive Circle, equal to 34d. 30m. is required?

Note; The given Point must be so far from the Center of the Primitive Circle, that the Tangent from the Center, and the Secant (of the same) from the given Punct, may intersect, or cut each other; otherwise 'tis impossible.

1. With the Tangent of 34d. 30m. and one Foot in A, make an Arch Y.

2. Then with the Secant of the same, and one Foot in F, cut the Arch Y, in Y, the Center of the Oblique Circle BFD, required to be drawn; and if B, and D, are diametrically opposite, 'tis done true, otherwise not.

Problem 4. *To draw a Great Circle, through any two Puncts given; either both within the Primitive Circle, or one within, and the other without.*

The Rule. 1. Draw a Line from the Primitive Circle's Center, thro' one (always the remotest) of the two Puncts, to cut the Primitive Circle, and produce it at Pleasure.

H

2. From

2. From the said Punct, draw another Line to a Punct in the Primitive Circle, that is god. distance from the first Line.
3. On the last Line, and at the Punct in the Primitive Circle, erect a Perpendicular, to cut the first Line in the third Punct.
4. Through the two given Puncts, and this last third Point, draw (by *Chapier 1. Sect 2. Problem 7. of Practical Geometry, in Page 15*) an Arch of a Circle, and 'tis done.

Example. *Plate 3. Fig. 9.*

BCDE the Primitive Circle }
 A the Center thereof — } given ;
 F and G, two Puncts — }

Through F and G 'tis required to draw a Great Circle ?

1. Thro' A and F, draw the Right Circle BFAD, to cut the Primitive Circle in B and D, and continue it further at Pleasure.
2. Lay the Chord of god. on the Primitive Circle from B, or from D, to C or E, and draw the Line FC or FE.
3. At C erect CH perpendicular to CF, or at E erect EH perpendicular to EF, to cut the Diameter BFAD in H, the third Punct.
4. Through F, G, and H, draw a Circle IFGKH, which will cut the Primitive Circle in I and K, diametrically opposite, and 'tis done.

Problem 5. To draw a Great Circle perpendicular to, or at Right Angles with a given Great Circle.

A General Rule. Draw a Great Circle through the Pole, or Poles of the given Great Circle, and 'tis perpendicular to it, or it makes a Right Angle with it.

Note, In this Problem are four Cases.

Problem 5. Case 1. To draw a Great Circle perpendicular to the Primitive Circle.

The Rule. This is done by drawing a Diameter thro' the Center of the Primitive Circle ; for the Center of the Primitive Circle being its Pole, all Right Lines drawn through the Center, are perpendicular Circles to the Primitive Circle.

Example. *Plate 3. Fig. 7.*

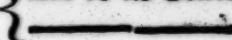
BCDE the Primitive Circle, and A its Center given ; To draw a great Circle perpendicular to it, is required ?

Through A draw the Right Circle BAD, and 'tis perpendicular to the Primitive Circle BCDE, as was required

Problem 5. Case 2. *To draw a Right Circle perpendicular to a given Right Circle.*

The Rule. This is done by drawing a Diameter at Right Angles to the given Right Circle; or quartering the Primitive Circle (by *Chapter 1, Section 2. Problem 8. of Practical Geometry*, in Page 15.) with two Diameters.

Example. Plate 3. Fig. 7.

BCDE the Primitive } Circle, { and A its Center } given;
BAD is a Right } 

To draw a Right Circle perpendicular to the Right Circle BAD, is required?

Draw the Diameter CAE perpendicular to BAD, or from the Chords lay *god.* on the Primitive Circle from B, or from D, to C and E, which are its two Poles, and through C, A, and E, draw a Diameter, and 'tis done.

Problem 5. Case 3. *To draw an Oblique Circle perpendicular to a given Right Circle.*

The Rule. 1. Find the two Poles of the given Right Circle, by *Problem 1. Case 2. of Spheric Geometry*, in page 111.

2. Draw an Oblique Circle through those two Poles, and 'tis done.

Example. Plate 3. Fig. 7.

BCDE the Primitive Circle }
A the Center thereof — } given;
BAD is a Right Circle — }

To draw an Oblique Circle, perpendicular to the Right Circle BAD, is required?

1. Take the Chord of *god.* and lay it from B, or D, both ways to C and E, which are the two Poles of the Right Circle BAD.

2. With any Distance, and one Foot on C, and E, draw Arches to cut each other in X, the Center of the Oblique Circle CGE, required to be drawn.

Note, If AG be known, or limited to a certain Distance, then 'tis done by drawing a Circle through the three Points C, G, and E.

Or, 2. If AG be any known Quantity of Degrees, then take the Secant of its Complement, and setting one Foot on C, or E, the other will cross the given Right Circle, in the Center of the Oblique Circle required to be drawn.

Problem 5. Case 4. *To draw an Oblique Circle, perpendicular to a given Oblique Circle.*

The Rule. 1. Find the two Poles of the given Oblique Circle, by *Prob. 1. Case 3. of Spheric Geometry*, in pages 111, and 112.

2. Through those Poles draw a great Circle, which will cut the Oblique Circle at Right Angles, and the Primitive Circle diametrically opposite, and 'tis done.

Example. Plate 3. Fig. 10.

BCDE the Primitive } Circle, and { A } its Center given ;
BFD an Oblique } { Y }

To draw another Oblique Circle perpendicular to the Oblique Circle BFD, is required ?

1. Find G, the Interior, and Exterior Pole of the given Oblique Circle BFD, by *Problem 1. Case 3. of Spheric Geometry*, in pages 111 and 112.

2. Through G, draw the Circle HIGK, to cut the Primitive in H and K, and the Oblique Circle BFD in I, (so that HAK is in a Diameter) and 'tis done ; for then the Angle BIH is a Right Angle, and the Oblique Circles BIFD, and HIGK, are perpendicular to one another.

Note ; 1. If the Punct I (on the given Oblique Circle) is given ; then draw a Circle through I, (and the Interior Pole G, (by *Problem 4. of Spheric Geometry*, in page 113.) and 'tis done.

Or, 2. If it be required, that the said Oblique Circle shall make a certain Angle at the Primitive Circle, then draw a Circle through the said Pole G, by *Prob. 3. of Spheric Geometry*, in page 113.

Problem 6. *To lay any Quantity of Degrees on any Great Circle.*
In this Problem are three Cases.

Problem 6. Case 1. *To lay any Quantity of Degrees on the Primitive Circle.*

The Rule. This is done by, or from the Scale of Chords.

Example. Plate 3. Fig. 8.

BCDE the Primitive Circle, and A it's Center given ;

To lay 40d. 30m. on the Primitive Circle from B is required ?

From the Scale of Chords, take 40d. 30m. and lay it on the Primitive Circle from B to C and it's done.

Problem 6. Case 2. *To lay any Quantity of Degrees on a Right Circle.*

The Rule. This is done from the Scale of Half Tangents, counting the Beginning thereof to be the Center of the Primitive Circle.

Example

Example. Plate 3. Fig. 11.

BCDE, the Primitive Circle, and A its Center } given;
BAD is a Right Circle ————— }

On the Right Circle BAD, from A, to lay 40d. 30m. or from B, to lay 49d. 30m. is required?

From the Half Tangents, take 49d. 30m. and lay it on the Right Circle BAD, from A to *l*; or 49d. 30m. the contrary Way of the Half Tangents, laid from B to *l*, and 'tis done. For A*l* and *l*B together are equal to 90 Degrees.

Problem 6. Case 3. *To lay any Quantity of Degrees on an Oblique Circle.*

The Rule. 1. Find the Poles of the given Oblique Circle, by Problem 1. Case 3. of *Spheric Geometry*, in pages 111 and 112.

2. Lay the given Quantity of Degrees on the Primitive Circle, by Case 1. of this Problem.

3. Reduce it from the Primitive Circle to the given Oblique Circle, by laying a Scale on either of its Poles. and 'tis done.

Example. Plate 3. Fig. 11.

BCDE the Primitive } Circle, and { A } its Center given.
BFD an Oblique } { Y }

On the Oblique Circle BFD (from B) to lay 51d. 30m. is required?

1. By A and Y, draw the Diameter CAE, and find G the Pole of the Oblique Circle, by Prob. 1. Case 3. in page 111.

2. From the Scale of Chords, take 51d. 30m. and lay it on the Primitive Circle, from B to H.

3. Lay a Scale on G and H, to cut the Oblique Circle BFD in I, then is BI (on the Oblique Circle) equal to 51d. 30m. as was required.

Problem 7. *To measure any Part of a Great Circle.*

In this Problem are three Cases, which are but the Converse of those in the last Problem.

Problem 7. Case 1. *To measure any Part of the Primitive Circle.*

The Rule. Take the Part required to be measured, and lay it on the Scale of Chords, and it sheweth how much it is.

Example. Plate 4. Fig. 8.

BCDE the Primitive Circle, and A its Center given;

To measure BC, a Part of the Primitive Circle, is required?

Take the Extent BC in the Compasses, and lay it on the Chords, which will shew how many Degrees BC doth measure.

Problem 7. Case 2. To measure any Part of a Right Circle.

The Rule. 1. If the Part to be measured lieth next the Center of the Primitive Circle, then 'tis measured on the Scale of Half-Tangents, from the Brass Center Pin at the beginning thereof.

2. When the Part to be measured lieth next to the Primitive Circle, then 'tis measured on the Scale of Half-Tangents, from 90d. counting 80d. to be 10d. 70 to be 20, 60 to be 30, &c.

Example. Plate 3. Fig. 7.

BCDE the Primitive Circle, and A its Center } given;
BAD a Right Circle ————— }

To measure Al , or Bl , on the Right Circle BAD , is required?

1. Take Al , and lay it on the Scale of Half-Tangents from the Brass Center Pin (at the beginning of it) which will shew how many Degrees it is. Or,

2. Take Bl , and lay it on the Scale of Half-Tangents from 90d. backwards, counting 80d. to be 10. and 70. to be 20, &c. which will shew how many Degrees Bl is. And,

Note, That Al and Bl , will make together just 90d. they being Complements to each other.

Problem 7. Case 3. To measure any Part of an Oblique Circle.

The Rule. 1. Find the Poles of the given Oblique Circle, by *Problem 1. Case 3. of Spheric Geometry*, in pages 111 and 112.

2. Lay a Scale on either of the said Poles, and the Part desired to be measured, and reduce it to the Primitive Circle.

3. Being thus reduced to the Primitive Circle, 'tis measured on the Scale of Chords, as before in *Case 1. of this Problem*.

Example. Plate 3. Fig. 11.

BCDE the Primitive } Circle, and { A } its Center given.
BIFD an Oblique } { Y }

To measure Bl , and Fl , on the Oblique Circle $BIFD$ is required?

4. Find G the Pole of the Oblique Circle $BIFD$, by *Prob. 1. Case 3. of Spheric Geometry*, in pages 111 and 112.

2. Lay a Scale on G and I , to cut the Primitive Circle in H .

3. Then

3. Then EH measured on the Scale of *Chords*, is the Measure of FI; and BH on the same Scale of *Chords* is the Measure of BI.

Problem 8. *To measure any Spheric Angle.*

In this Problem are four Cases; and this is

A General Rule. A Spheric Angle is measured by the Arch of a great Circle, intercepted between the two containing Sides, the Angular Punct being the Pole of that Circle. Or the Distance of the Poles of the containing Sides, is equal to the Measure of the contained Angle.

Problem 8. Case 1. *To measure an Angle, when its Angular Punct is the Center of the Primitive Circle.*

The Rule. Such an Angle is measured (like a Plain Angle) on the primitive Circle, by a Scale of *Chords*.

Example. Plate 3. Fig. 8.

BCDE the primitive Circle, A its Center, and the Angular Punct given; to measure the Angle BAC is required?

Take BC, and measure it on the Scale of *Chords*, shews the Angle BAC, how much it is.

Problem 8. Case 2. *To measure an Angle, when its Angular Punct is at the Primitive Circle.*

The Rule. 1. Find the Poles of the two containing Sides, by Problem 1. of Spheric Geometry, in Pages 111 and 112.

2. The Distance of those two Poles, is the Measure of the required Angle.

Note 1. When the two Poles are in one Diameter, or Right Circle, 'tis measured on the Scale of Half Tangents.

2. When they are not in one Diameter, then reduce them to the primitive Circle, by laying a Scale on the Angular Punct, and the said two Poles, which Distance being measured, on the Scale of *Chords*, is the Measure of the required Angle.

Example. Plate 3. Fig. 8.

BCDE the Primitive } Circle, and { A } its Center given,
BGFD an Oblique } { Y }

To measure the Angle EDF, equal to the Angle EBF is required.

1. Through A and Y, draw a Diameter to cut the primitive Circle in H and I, and the Oblique Circle in G.

2. In the Diameter IAH, find K, the Pole of the Oblique Circle BGFD.

H 4

3. The

3. The Distance AK, or GI, measured on the Scale of Half-Tangents, (the latter the contrary Way on that Scale from 90d.) sheweth how much the Angle EDF, or EBF is.

Problem 8. Case 3. *To measure an Angle when its Angular Point is not in the Center of, nor at the Primitive Circle.*

The Rule is this: 1. Find the two Poles of the two containing Sides, by *Problem 1.* in *pages 111 and 112.*

2. Reduce those two Poles to the Primitive Circle, then measure the Distance of them on a Scale of Chords, and 'tis done.

Note, Reduce, is to lay a Scale on the Angular Point (required to be measured) and the said two Poles, to cut the Primitive Circle.

Example. *Plate 3. Fig. 8.*

BCDE the Primitive } Circle, and } A } its Center — }
 BGFD an Oblique } } Y }
 CAFE a Right } cuts the Oblique in F. } given;
 To measure the Angle DFE, or BFE is required?

1. Through A and Y, draw the Diameter IAH, and in it find K the Interior Pole of the Oblique Circle BGFD, as before in the last Case.

2. Find L the Pole of the Right Circle CAFE, by *Problem*
1. Case 2. of *Spheric Geometry*, in page III.

3. Reduce K to the Primitive Circle (by laying a Scale on F and K, to cut the Primitive Circle) and 'tis M: Then LM measured on the *Chords*, sheweth how much the Angle DFE, or BFE, is; one Acute, and the other Obtuse.

Problem 8. Case 4. *To measure an Angle, when the containing Sides are both Oblique Circles.*

Example. *Plate 3. Fig. 12.*

BCDE the Primitive } Circle, and { A } its Center given;
 CHFE an Oblique } { Y }
 BGFD an Oblique } { X }

1. By A, and Y; and A, and X, draw two Diameters; in them find I, and K, the two Interior Poles of the containing Sides, by *Problem 1. Case 3. of Spheric Geometry*, in *pages 111 and 112.*

2. Reduce those two Poles, I and K, (by laying a Scale on the Angular Point F, and them) to cut the Primitive Circle in L and M : which being measured on the *Chords*, sheweth how much the Angle DFE, or BFE, is ; one Acute, the other Obtuse. Problem

Problem

Problem 9. To draw a Parallel Circle.

Definition. A Parallel Circle or a lesser Circle, cutteth the Sphere into two unequal Parts, and lieth parallel to a Great Circle.

In this Problem are three Cases.

Problem 9. Case 1. To draw a Circle parallel to the Primitive Circle, at any given Distance from it, or from its Pole.

The Rule. With the Half-Tangent of its Distance from the Pole, and one Foot on the Center of the Primitive Circle, draw a Circle, and 'tis done.

Example. Plate 3. Fig. 7.

BCDE the Primitive Circle, A its Center given; to draw a Circle parallel to BCDE, at 30d. distance from it, is required?

With the Half Tangent of 60d. (the Complement of 30d. and) its Distance from the Pole of the Primitive Circle, set one Foot in A (the Center, and Pole of the Primitive Circle) and describe the Circle *lmno*, which is parallel, as required?

Problem 9. Case 2. To draw a Circle parallel to a Right Circle.

The Rule. 1. From the Chords lay the Parallel's Distance from the Right Circle, or the Complement thereof, from one of the Poles of the Right Circle, both Ways, and note those two Marks on the Primitive Circle.

2. With the Tangent of the parallel's Distance from the Pole of the Right Circle, and one Foot on each of those two Marks, describe Arches to cut each other, in the Center of the parallel Circle required to be drawn.

Example. Plate 3. Fig. 7.

BCDE the Primitive Circle, and A its Center } given;
BAD is a Right Circle ————— }

To draw a Circle parallel to BAD, at 40d. distance from it, or 50d. Distance from C, its Pole, is required?

1. Lay 40d. from B to *p*, and from D to *q*; or lay its Complement 50d. from C, one of the Poles of the Right Circle, both Ways to the said *p* and *q*.

With the Tangent of 50d. and one Foot on { *p* } make
the Arch *y*; which Point of Intersection at *y*, is the Center of
the parallel Circle *p r q*, required to be drawn.

Problem

Problem 9. Case 3. To draw a Circle parallel to an Oblique Circle.

The Rule. 1. Find the Interior Pole of the given Oblique Circle, by *Problem 1. Case 3.* in *Pages 111 and 112*, which reduce to the Primitive Circle, and therefrom lay the Parallels Distance from the Pole both Ways, which being reduced to the Right Circle, is the Diameter of the Parallel Circle.

2. Find the middle of the said Diameter, which is the Center of the Parallel Circle passing through those Marks, and 'tis done.

Example. Plate 3. Fig. 11.

BCDE the Primitive } Circle, and { A } its Center given ;
BFD an Oblique } { Y }

To draw a Circle parallel to BFD, at 40d. Distance from it, or 50d. Distance from its Pole is required ?

1. Find G the Pole of the given Oblique Circle BFD, by *Problem 1. Case 3.* of *Spheric Geometry*, in *Pages 111 and 112*.

2. Measure AG on the Half Tangents, and suppose it to be 30d. then add 50 to it, and subtract it from 50 ; the Sum 80d. lay from A to k ; and the Difference 20d. lay from A to l. Or thus ; Reduce G to the primitive Circle, and from it lay 50d. both Ways, which reduce to the Right Circle, gives the same Points k and l.

3. Find m the middle between k and l, and on m as a Center, draw a Circle to pass through k and l, which is the Parallel Circle required to be drawn.

Thus much for *Problems* necessary for the making and measuring *Spheric Triangles* ; which I advise the Learner to acquaint himself with, and then the following Applications will be the better understood.

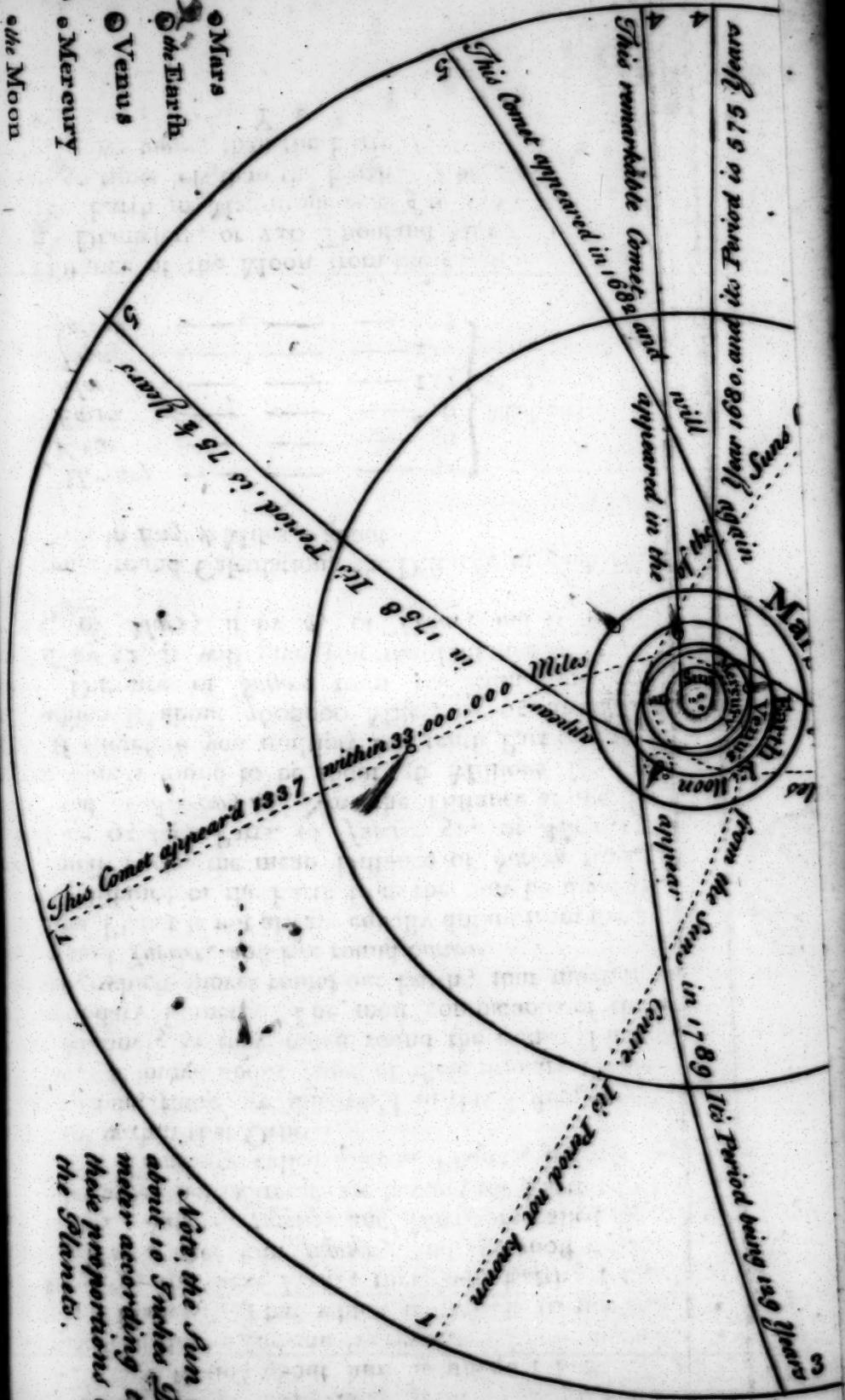
Section II. *The Use of the Nine preceding Problems, in making any Spheric Triangle, and measuring its Parts ; or the Doctrine of Spheric Triangles Geometric.*

Definition 1. A Sphere or Globe, is a round Body made by the moving a Semi-circle about its own Diameter, 'till the Motion end where it first began. The Semi-circle's Diameter is the Axis, or Diameter of the Sphere ; in the middle of which is a Point, called the Center ; from whence all Right Lines drawn to the Surface, or Outside of the Sphere, are equal.

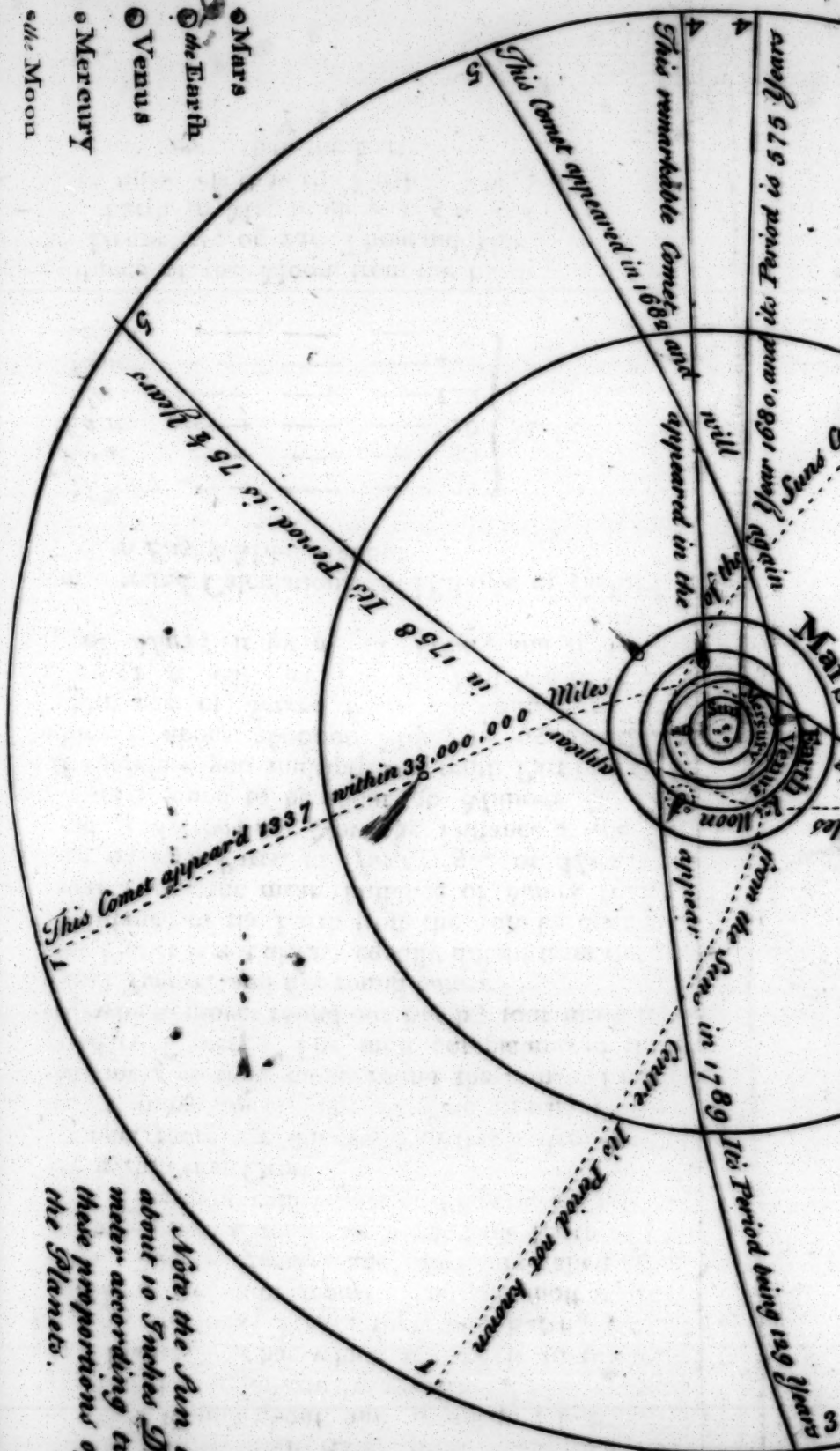
2. A *Spheric Triangle*, is described on the Surface of the Sphere, whose Sides are the Arches of three great Circles, mutually

Magnitudes

- ☿ Mars
- ♁ the Earth
- ♀ Venus
- ☿ Mercury
- ☾ the Moon



☿ Mars
 🌍 the Earth
 ♀ Venus
 ☿ Mercury
 🌙 the Moon



Note, the Sun is about 10 Inches Diameter according to those proportions of the Planets.

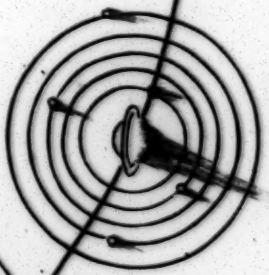
The SOLAR SYSTEM with the Orbits of 5 remarkable COMETS.

In this Scheme the Orbits of the Planets are drawn according to their mean distances from the Sun, and the Planets themselves in the proportions they bear to each other.

Saturn



Saturn and his 5 Moons



Jupiter



Jupiter and his 4 Moons



Sun's Centre. Its Period not yet known

Mars
Earth
Venus
Mercury

545 to 575 Years
1080, and its Period is 40,000 Miles
1661 and will 000 Miles
159 Years

This Comet appeared 1590 within 40,000 Miles
This Comet appeared in 1661 and will 000 Miles
again



mutually intersecting each other; and is either Quadrantal, Rectangular, or Obliquangular.

3. $\left\{ \begin{array}{l} \text{A Quadrantal} \\ \text{A Rectangle} \\ \text{An Obliquangular} \end{array} \right\}$ Triangle hath $\left\{ \begin{array}{l} \text{one Side} \\ \text{one Angle} \\ \text{no Side a Quadrant,} \end{array} \right\}$ 90d.
or 90d. nor any Angle 90d.

Note 1. In every Spheric Triangle, each Side is less than a Semicircle, or 180 Degrees.

2. The Sum of any two Sides is greater than the Third Side.

3. The three Sides added together, their Sum is less than 360 Degrees.

4. The Sum of the three Angles, is ever more than two Right Angles, or 180d. but always less than six Rights, or 540 Degrees.

Problem 10. *The Hypotenuse, and one Leg given; to make a Rectangular Spheric Triangle.*

Note, To make a Rectangle Spheric Triangle, two Things (besides the Rectangle) must be given.

Example. *Plate 4. Fig. 1.*

The $\left\{ \begin{array}{l} \text{Hypotenuse } AC \text{ } 54d. \text{ } 25m. \\ \text{Leg } BC \text{ } \text{---} \text{ } 23d. \text{ } 30m. \end{array} \right\}$ given;

With them to make a Rectangle Spheric Triangle is required?

1. Draw the Primitive Circle with a Chord of 60d. a Sine of 90d. or with a Half Tangent of 90d. and quarter it, which must be done in every *Problem*.

Then consider, whether one of the Oblique Angles shall be at the Primitive Circle, or at its Center.

First, If at the Center of the Primitive Circle, then

1. Draw (by *Problem 9. Case 1. of Spheric Geometry*) a Circle parallel to the Primitive, at 54d. 25m. (the given Hypotenuse) Distance from its Pole; that is, with the Half Tangent of 54d. 25m. and one Foot on A (the Center of the Primitive Circle) describe a Circle.

2. Then (by the 2d *Case* of the aforesaid *Problem*) draw a Circle parallel to a Right Circle, at 23d. 30m. (the given Leg) distance from it; These two parallel Circles cut each other in C.

3. Through A and C, draw a Great Circle, which in this Case is a Right Circle; that is, a Diameter: And from C (by *Problem 5. Case 1. of Spheric Geometry* in page 115.) draw a great

a great Circle perpendicular, or at Right Angles to AB, which in this Case will be an Oqlique Circle, and 'tis done.

Or,

Secondly, To make the Triangle, that one of its Oblique Angles may be at the Primitive Circle.

1. The Circle being described, and quartered as before directed. Then,

2. Draw (by *Problem 9. of Spheric Geometry*) a Circle parallel to a Right Circle, at 54d. 25m. distance from A its Pole.

3. And by the aforesaid *Problem*) draw a Circle parallel to the Primitive Circle, at 23d. 30m. distance from it, that is, take 66d. 30m. from the Scale of Half-tangents, and with one Foot on the Center draw a Circle, to cut the former Parallel Circle in C.

4. Then through A and C draw a Great Circle, which in this Case will be an Oblique Circle; and from C (by *Prob. 5. Case 1. of Spheric Geometry*, in page 114) draw a Great Circle perpendicular to AB; which in this Case will be a Right Circle, and 'tis done

To measure the Things required.

The { Leg AB ————— } is measured } 7. page 117.
 { Angles BAC and ACB } by *Problem* } 8. page 118, 119.

Problem 11. The Hypotenuse and one Angle given; to make a Triangle.

Example. Plate 4. Fig. 2.

The { Hypotenuse AC 54d. 25m. } given;
 { Angle BAC — 29d. 30m. }

With them to make a Rectangular Spheric Triangle, is required?

First, To make the Triangle, that the given Angle BAC may be at the Primitive Circle's Center.

1. Having described the Primitive Circle, and quarter'd it, as before directed in *Problem 10.* make the Angle BAC equal to 29d. 30m. (by *Problem 2. Case 1.* in page 112. of *Spheric Geometry*;) that is, from the Scale of Chords. lay 29d. 30m. on the Primitive Circle, and therefrom draw a Line through A, the Center of the Primitive Circle.

2. Make AC equal to 54d. 25m. (by *Problem 6. Case 2.* in page 116. of *Spheric Geometry*;) that is, from the Scale of Half Tangents, lay 54d. 25m. from A to C.

3. By *Problem 5. Case 3.* in page 115. draw a Circle from C, perpen-

perpendicular unto AB, to cut the Right Circle AB in B; which in this *Case* is an *Oblique Circle*, and it's done.

Secondly, To make the Triangle so, that the given Angle may be at the Primitive Circle.

1. After the Primitive Circle is made, and quarter'd as before, let A be one of those Marks or Quarters: Then (by *Problem 2. Case 2.* in page 112.) make the Angle at A equal to 29d. 30m. by drawing an *Oblique Circle* with the Secant of the given Angle, as in the *Oblique Circle AC*.

2. Then (by *Problem 6. Case 3.* in page 117.) lay 54d. 25m. on the *Oblique Circle* from A to C. Or, draw (by *Problem 9. Case 2.* in page 121.) a Circle parallel to a Right Circle, at 54d. 25m. distance from A, its Pole, to cut the *Oblique Circle AC* in C.

3. By *Problem 5. Case 1.* in page 114, draw a Circle from C, perpendicular to the Primitive Circle AB, to cut AB, in B; which in this *Case* is a Right Circle, and 'tis done.

To measure the Things required,

The { Leg AB, and BC } is measured by *Prob.* { 7. } page 117.
 { Angle ACB ——— } { 8. } page 119.

Problem 12. A Leg, and its adjacent Angle given; to make a Triangle. Example. Plate 4. Fig. 3.

The { Leg AB—50d. 30m. }
 { Angle BAC 29d. 30m. } given;

With them to make a Rectangle Spheric Triangle is required?

First, To make the Triangle, that the given Angle (BAC) may be at the Primitive Circle's Center.

1. The Primitive Circle being described, and quartered as before, and A placed at its Center; then (by *Problem 2. Case 1.* in page 112. of *Spheric Geometry*) make the Angle BAC equal to 29d. 30m. by drawing the Right Circle AC.

2. By *Problem 6. Case 2.* in page 116, make AB equal to 50d. 30m. that is, from the Scale of Half Tangents, lay 50d. 30m. on the Right Circle from A to B.

3. By *Problem 5. Case 3.* in page 115, draw from B, an *Oblique Circle BC*, perpendicular to the Right Circle AB, to cut the Right Circle AC in C, and it's done. Or thus,

From the Scale of Secants, take 39d. 30m. (the Complement of AB 50d. 30m.) setting one Foot in B, the other Foot marks out (on the Right Circle AB extended) the Center of the *Oblique Circle BC*, which concludes the Triangle.

Secondly, To make the Triangle so, that the given Angle may be at the Primitive Circle.

1. A being on, or at the Primitive Circle, then by *Problem 2. Case 2. in page 112.* make the Angle BAC equal to 29d. 30m. by drawing the Oblique Circle AC, with the Secant thereof.

2. By *Problem 6. Case 1. in page 116.* make AB (on the Primitive Circle) equal to 50d. 30m. by laying the Chord of it from A to B.

3. By *Problem 5. Case 1. in page 114.* draw a great Circle from B, perpendicular to AB, as the Right Circle BC, to cut the Oblique Circle AC in C, and 'tis done.

To measure the Things required.

The $\left\{ \begin{array}{l} \text{Leg BC, and Hyp. AC} \\ \text{Angle ACB} \end{array} \right\}$ is measured by *Problem* $\left\{ \begin{array}{l} 7. \\ 8. \end{array} \right\}$ in pages 118 and 120.

Problem 13. A Leg, and its opposite Angle given; to make a Triangle.

Example. *Plate 4. Fig. 2.*

The $\left\{ \begin{array}{l} \text{Leg BC} - 23d. 30m. \\ \text{Angle BAC } 29d. 30m. \end{array} \right\}$ given;

With them to make a Rectangle Spheric Triangle, is required?

First, To make the Triangle, with the given Angle at the Primitive Circle's Center.

1. The Primitive Circle drawn, &c. as before, and A at its Center, (by *Problem 2. Case 1. in page 112.*) make the Angle BAC equal to 29d. 30m. by drawing two Right Circles AB, and AC.

2. Draw by *Problem 9. Case 2. in page 121.* (a Parallel Circle, parallel to the Right Circle AB, at 23d. 30m. distance from it, to cut AC in C.

3. From C (by *Problem 5. Case 3. in page 115*) draw an Oblique Circle BC, perpendicular to the Right Circle AB to cut AB in B; and 'tis done.

Secondly, To make the Triangle, that the given Angle may be at the Primitive Circle.

1. A, being at the Primitive Circle, (by *Prob. 2. Case 2. in page 112.*) make the Angle BAC equal to 29d. 30m. by drawing the Oblique Circle AC, with the Secant thereof.

2. By *Problem 9. Case 1. in page 121.* draw a Parallel Circle, parallel to the Primitive Circle AB at 23d. 30m. distance from it, to cut the Oblique Circle AC in C. Or thus, with the Half Tangent of 66d. 30m. (the Complement of 23d. 30m.) and one Foot in the Center of the Primitive Circle, with the other cut the Oblique Circle in C.

3. From C (by *Problem 5. Case 1. in page 114.*) draw a Right Circle

Circle *BC*, perpendicular to the Primitive Circle *AB*, to cut *AB* in *B*, and 'tis done.

To measure the Things required.

The $\left\{ \begin{array}{l} \text{Hypot. } AC, \text{ and Leg } AB \\ \text{Angle } ACB \end{array} \right\}$ is measured by *Problem* $\left\{ \begin{array}{l} 7. \\ 8. \end{array} \right\}$ in *Pages* 117, 118 and 119.

Problem 14. Both Legs given, to make a Spheric Triangle.

Example Plate 4. Fig. 5.

The Leg $\left\{ \begin{array}{l} AB \text{ 50d. 30m.} \\ BC \text{ 23d. 30m.} \end{array} \right\}$ given;

With them to make a Rectangle Spheric Triangle is required?

First, To make the Triangle, that one of the Oblique Angles may be at the Primitive Circle's Center.

1. *A*, being at a Center of the Primitive Circle, draw the Right Circle *AB*, and thereon (by *Problem 6. Case 2. in Page 116.*) make *AB* equal to 50d. 30m. by laying the Half Tangent thereof from *A* to *B*.

2. From *B* (by *Problem 5. Case 3. in Page 115.*) draw an Oblique Circle *BC* perpendicular to *AB*. Or thus,

With the Secant of 39d. 30m. (the Complement of 50d. 30m.) and one Foot on *B*, the other Foot marks out (in the Right Circle *AB* extended) the Center of the Oblique Circle *BC*.

3. Draw (by *Problem 9. Case 2. in Page 121.*) a Parallel Circle, parallel to the Right Circle *AB*, at 23d. 30m. distance from it, to cut the Oblique Circle *BC* in *C*. Or thus,

By *Problem 6. Case 3. in Page 117.* lay 23d. 30m. on the Oblique Circle, from *B* to *C*.

4. Through *A* and *C* draw a great Circle; which in this Case is a Right Circle, and 'tis done.

Secondly, To make the Triangle, that one of the Oblique Angles may be at the Primitive Circle.

1. By *Problem 6. Case 1. Page 116.* make *AB* equal to 50d. 30m. by laying the Chord therefore on the Primitive Circle, from *A* to *B*.

2. From *B* (by *Problem 5. Case 1. in Page 114.*) draw a Great Circle perpendicular to the Primitive Circle, (which in this Case is a Right Circle) as *BC*.

3. Draw (by *Problem 9. Case 1. in Page 121.*) a Parallel Circle, parallel to the Primitive Circle *AB*, at 23d. 30m. distance from it, to cut the Right Circle *BC* in *C*. Or thus,

From the Scale of Half Tangents, lay 66d. 30m. (the Complement of 23d. 30m.) from the Center of the Primitive Circle, on the Right Circle to *C*.

4. Through

1. A being on, or at the Primitive Circle, then by *Problem 2. Case 2. in page 112.* make the Angle BAC equal to 29d. 30m. by drawing the Oblique Circle AC, with the Secant thereof.

2. By *Problem 6. Case 1. in page 116.* make AB (on the Primitive Circle) equal to 50d. 30m. by laying the Chord of it from A to B.

3. By *Problem 5. Case 1. in page 114.* draw a great Circle from B, perpendicular to AB, as the Right Circle BC, to cut the Oblique Circle AC in C, and 'tis done.

To measure the Things required.

The { Leg BC, and Hyp. AC } is measured by *Problem { 7. }
{ Angle ACB ————— } 8. }*
in pages 118 and 120.

Problem 13. A Leg, and its opposite Angle given; to make a Triangle.

Example. *Plate 4. Fig. 2.*

The { Leg BC — 23d. 30m. } given;
{ Angle BAC 29d. 30m. }

With them to make a Rectangle Spheric Triangle, is required?

First, To make the Triangle, with the given Angle at the Primitive Circle's Center.

1. The Primitive Circle drawn, &c. as before, and A at its Center, (by *Problem 2. Case 1. in page 112.*) make the Angle BAC equal to 29d. 30m. by drawing two Right Circles AB, and AC.

2. Draw by *Problem 9. Case 2. in page 121.* (a Parallel Circle, parallel to the Right Circle AB, at 23d. 30m. distance from it, to cut AC in C.

3. From C (by *Problem 5. Case 3. in page 115*) draw an Oblique Circle BC, perpendicular to the Right Circle AB to cut AB in B; and 'tis done.

Secondly, To make the Triangle, that the given Angle may be at the Primitive Circle.

1. A, being at the Primitive Circle, (by *Prob. 2. Case 2. in page 112.*) make the Angle BAC equal to 29d. 30m. by drawing the Oblique Circle AC, with the Secant thereof.

2. By *Problem 9. Case 1. in page 121.* draw a Parallel Circle, parallel to the Primitive Circle AB at 23d. 30m. distance from it, to cut the Oblique Circle AC in C. Or thus, with the Half Tangent of 66d. 30m. (the Complement of 23d. 30m.) and one Foot in the Center of the Primitive Circle, with the other cut the Oblique Circle in C.

3. From C (by *Problem 5. Case 1. in page 114.*) draw a Right Circle

Circle *BC*, perpendicular to the Primitive Circle *AB*, to cut *AB* in *B*, and 'tis done.

To measure the Things required.

The $\left\{ \begin{array}{l} \text{Hypot. } AC, \text{ and Leg } AB \\ \text{Angle } ACB \end{array} \right\}$ is measured by *Problem* $\left\{ \begin{array}{l} 7. \\ 8. \end{array} \right\}$ in *Pages* 117, 118 and 119.

Problem 14. *Both Legs given, to make a Spheric Triangle.*

Example Plate 4. Fig. 5.

The Leg $\left\{ \begin{array}{l} AB \text{ 50d. 30m.} \\ BC \text{ 23d. 30m.} \end{array} \right\}$ given;

With them to make a Rectangle Spheric Triangle is required?

First, To make the Triangle, that one of the Oblique Angles may be at the Primitive Circle's Center.

1. *A*, being at a Center of the Primitive Circle, draw the Right Circle *AB*, and thereon (by *Problem 6. Case 2. in Page 116.*) make *AB* equal to 50d. 30m. by laying the Half Tangent thereof from *A* to *B*.

2. From *B* (by *Problem 5. Case 3. in Page 115.*) draw an Oblique Circle *BC* perpendicular to *AB*. Or thus,

With the Secant of 39d. 30m. (the Complement of 50d. 30m.) and one Foot on *B*, the other Foot marks out (in the Right Circle *AB* extended) the Center of the Oblique Circle *BC*.

3. Draw (by *Problem 9. Case 2. in Page 121.*) a Parallel Circle, parallel to the Right Circle *AB*, at 23d. 30m. distance from it, to cut the Oblique Circle *BC* in *C*. Or thus,

By *Problem 6. Case 3. in Page 117.* lay 23d. 30m. on the Oblique Circle, from *B* to *C*.

4. Through *A* and *C* draw a great Circle; which in this Case is a Right Circle, and 'tis done.

Secondly, To make the Triangle, that one of the Oblique Angles may be at the Primitive Circle.

1. By *Problem 6. Case 1. Page 116.* make *AB* equal to 50d. 30m. by laying the Chord therefore on the Primitive Circle, from *A* to *B*.

2. From *B* (by *Problem 5. Case 1. in Page 114.*) draw a Great Circle perpendicular to the Primitive Circle, (which in this Case is a Right Circle) as *BC*.

3. Draw (by *Problem 9. Case 1. in Page 121.*) a Parallel Circle, parallel to the Primitive Circle *AB*, at 23d. 30m. distance from it, to cut the Right Circle *BC* in *C*. Or thus,

From the Scale of Half Tangents, lay 66d. 30m. (the Complement of 23d. 30m.) from the Center of the Primitive Circle, on the Right Circle to *C*.

4. Through

4. Through A and C, draw a great Circle; which in this Case is an *Oblique Circle*, and 'tis done.

To measure the Things required.

The $\left\{ \begin{array}{l} \text{Hypotenuse AC} \\ \text{Angle BAC, and ACB} \end{array} \right\}$ is measured by Problem $\left\{ \begin{array}{l} 7. \\ 8. \end{array} \right\}$ in pages 117, 118, and 119.

Problem 15. *Both the Angles given; to make a Spheric Triangle.*

Example. Plate 4. Fig. 8.

The Angle $\left\{ \begin{array}{l} \text{BAC } 29^{\text{d.}} \ 30^{\text{m.}} \\ \text{ACB } 71^{\text{d.}} \ 56^{\text{m.}} \end{array} \right\}$ given;

with them to make a Rectangle Spheric Triangle, is requir'd?

1. By Problem 2. Case 2. in page 112, make the Angle BAC equal to $29^{\text{d.}} \ 30^{\text{m.}}$ by drawing the *Oblique Circle* AB, with the Secant thereof.

2. Find I, the Pole of the *Oblique Circle* AB, by Problem 1. Case 3. in pages 111 and 112.

3. Through I (by Problem 3. in page 113.) draw an *Oblique Circle* IBC, that the Angle ACB may be $71^{\text{d.}} \ 56^{\text{m.}}$ which will cut the *Oblique Circle* AB, in B the Rectangle, and the Primitive Circle in C, and so conclude the Rectangle Spheric Triangle ABC, required to be made.

To measure the Things required.

The Hypotenuse AC, and Legs AB, and BC, are measured by Problem 7. of *Spheric Geometry*, in pages 117 and 118.

Thus, all the Cases of Rectangle Spheric Triangles may be described, and resolved by the last Six Problems. In like manner, the Cases of Oblique Spheric Triangles may be Geometrically solved by the Six following.

Problem 16. *Two Sides, and an Angle opposite given; to make an Oblique Spheric Triangle.*

Note; To make an Oblique Spheric Triangle, three Things must be given.

Note also, The Angle opposite to the other given Side ought to be foreknown, whether Acute or Obtuse: otherwise two several Triangles may be made from the given Things.

Example. Plate 4. Fig. 7.

The $\left\{ \begin{array}{l} \text{Side AC } 34^{\text{d.}} \ 07^{\text{m.}} \\ \text{Side AD } 65^{\text{d.}} \ 20^{\text{m.}} \\ \text{Angle ADC } 27^{\text{d.}} \ 30^{\text{m.}} \end{array} \right\}$ given;

With them to make a Spheric Triangle (so that the Angle ACD may be Obtuse) is required?

1. On the Primitive Circle, make AD (the given Side joining to the given Angle) equal to 65d. 20m. by Problem 6. Case 1. of Spheric Geometry, in page 116.

2. By Problem 2. Case 2. in page 112. make the Angle ADC equal to 27d. 30m. by drawing the Oblique Circle DC, with the Secant thereof.

3. Draw (by Problem 9. Case 2. in page 121.) a Parallel Circle at 34d. 07m. distance from A, to cut the Oblique Circle DC, in C.

4. Through A and C, draw a great Circle, and 'tis done.

To measure the Things required.

The { Angle CAD, and ACD } is measured by Problem { 8. }
 { Side CD ————— } { 7. }
 in pages 118 and 119.

Problem 17. *Two Angles, and one Side opposite given; to make an Oblique Spheric Triangle.*

Example. Plate 4. Fig. 8.

The { Angle CAD 30d. 48m. }
 { Angle ADC 27d. 30m. } given;
 { Side CD — 38d. 28m. }

With them to make an Oblique Spheric Triangle; so that the Side AC may be less than a Quadrant, or 90d. is required?

1. By Prob. 2. Case 2. in Page 112. make the Angle ADC equal to 27d. 30m. (always the Angle joining to the given Side) by drawing the Oblique Circle DC, with the Secant of it.

2. Draw (by Prob. 9. Case 2. in page 121.) a Parallel Circle at 38d. 28m. distance from D, to cut the Oblique Circle DC, in C.

3. Then through C (by Prob. 3. in page 113.) draw a great Circle to make an Angle at the Primitive Circle, that may be equal to 30d. 48m. as is the Oblique Circle CA, and 'tis done.

To measure the Things required.

The { Side AC, and AD } is measured by Problem { 7. }
 { Angle ACD ——— } { 8. }
 in pages 118 and 119.

Note; In these two last Problems, the three given Things without the Quality of a Fourth, are not sufficient to make a Triangle: And the Quality of the Fourth is not always discoverable by the given Things; therefore they are called *Doubtful Cases*.

Problem 18. *Two Sides, and one Angle between them given; to make an Oblique Spheric Triangle.*

I

Examp.

Example. Plate 4. Fig. 9.

The $\left\{ \begin{array}{l} \text{Side} \text{---} AC \text{ } 34\text{d. } 06\text{m.} \\ \text{Side} \text{---} AD \text{ } 65\text{d. } 20\text{m.} \\ \text{Angle } CAD \text{ } 30\text{d. } 46\text{m.} \end{array} \right\}$ given ;

With them to make an *Oblique Spheric Triangle* is required ?

1. By *Problem 2. Case 2.* in page 112. make the Angle CAD equal to 30d. 46m. by drawing the *Oblique Circle* AD with the Secant thereof.

2. Make AC (on the *Primitive Circle*) equal to 34d. 06m. and AD (on the *Oblique Circle*) equal to 65d. 20m. by *Problem 6. Case 1.* and 3. in pages 116 and 117.

3. Through C and D, draw a great Circle, and 'tis done.

To measure the Things required.

The $\left\{ \begin{array}{l} \text{Side} \text{---} CD \text{---} \\ \text{Angles } ACD, \text{ and } ADC \end{array} \right\}$ is measured by *Problem* $\left\{ \begin{array}{l} 7. \\ 8. \end{array} \right\}$ in Pages 118 and 119.

Problem 19. Two Angles, and one Side between them given ; to make an Oblique Spheric Triangle.

Example. Plate 4. Fig. 10.

The $\left\{ \begin{array}{l} \text{Angle } ACD \text{ } 131\text{d. } 34\text{m.} \\ \text{Angle } ADC \text{ } 27\text{d. } 30\text{m.} \\ \text{Side} \text{---} CD \text{ } 38\text{d. } 28\text{m.} \end{array} \right\}$ given ;

With them to make an *Oblique Spheric Triangle* is required ?

1. On the *Primitive Circle*, make CD equal to 38d. 28m. the given Side, by *Problem 6. Case 1.* in page 116.

2. At D (by *Prob. 2. Case 2.* in pages 112 and 113) make the Angle ADC equal to 27d. 30m. by drawing the *Oblique Circle* DA ; and at C, make the Angle ACD equal to 131d. 34m. by drawing the *Oblique Circle* AC, and 'tis done.

To measure the Things required.

The $\left\{ \begin{array}{l} \text{Side } AC, \text{ and } AD \\ \text{Angle } CAD \text{---} \end{array} \right\}$ is measured by *Prob.* $\left\{ \begin{array}{l} 7. \\ 8. \end{array} \right\}$ in pages 118 and 119.

Problem 20. Three sides given ; to make an Oblique Spheric Triangle. Example Plate 4. Fig. 11.

The Side $\left\{ \begin{array}{l} AD \text{ } 65\text{d. } 20\text{m.} \\ CD \text{ } 38\text{d. } 26\text{m.} \\ AC \text{ } 34\text{d. } 08\text{m.} \end{array} \right\}$ given ;

With them to make an *Oblique Spheric Triangle* is required ?

1. On the *Primitive Circle* make AD equal to 65d. 20m. (the greater given Side) by *Prob. 6. Case 1.* in page 116.

2. Draw (by *Prob. 9. Case 2.* in page 121.) a *Parallel Circle*, at 34d. 08m. distance from A ; and likewise another at 38d. 26m. distance from D, to cut each other in C.

3. Through A and C, and also D and C, draw great Circles, which will form the Spheric Triangle required.

To measure the Things required.

1. Find (by Problem 1, in pages 111 and 112.) the Poles of the three Sides of the Triangle ACD; that is, E the Pole of AD, F the Pole of AC, and G the Pole of CD.

2. Through F and G, draw a great Circle of which the angular Point C is its Pole, and you will form the Triangle EFG.

3. The Sides of the Triangle EFG, are equal to the Angles of the Triangle ACD; and the Angles of the first, are equal to the Sides of the latter, only the greater Angle in the one, is equal to the Supplement (of the greater Side in the other) to a Semi-circle.

That is; the Side EF is equal to the Angle CAD, the Side EG is equal to the Angle ADC, and the Side FG is equal to the Supplement to 180d. of the Angle ACD.

4. The Sides EF, EG, and FG, are measured by Problem 7, in pages 117 and 118,

Problem 21. *Three Angles given; to make an Oblique Spheric Triangle.* Example. Plate 4. Fig. 12.

The Angle $\left\{ \begin{array}{l} \text{CAD } 131^{\text{d.}} 34^{\text{m.}} \\ \text{ACD } 30^{\text{d.}} 45^{\text{m.}} \\ \text{ADC } 27^{\text{d.}} 30^{\text{m.}} \end{array} \right\}$ given;

With them to make an Oblique Spheric Triangle, is required?

1. Suppose a Triangle EFG, whose Sides are equal to the Angles of the Triangle ADC; that is, the Side EF equal to 48d. 26m. the Supplement to 180d. of the Angle CAD equal to 131d. 34m. and the Side EG equal to the Angle ACD 30d. 45m. and the Side FG equal to the Angle ADC 27d. 30m.

2. Then, make the Triangle EFG of the Sides EF, EG and FG, as before in the last Problem.

3. Find (by Problem 1.) the Poles of the three Sides of the Triangle EFG; that is, A the Pole of EF, C the Pole of EG, and D the Pole of FG.

4. Through C and D, draw a great Circle, of which the angular Point G is its Pole, which will form the Triangle ACD required to be made.

To measure the Things required.

The Sides AC, AD, and CD, are measured by Problem 7. in pages 117 and 118.

Thus much I thought necessary as preparative to Spheric Trigonometry by Calculation; that the Learner might know

how to make, and measure a Spheric Triangle, or any of its Parts; a Thing not taught by many, nor well understood by more, who pretend to be Teachers.

Section III. *Of the Affections, or Natural Properties of Spheric Triangles.*

THese *Affections* are carefully to be minded, in order to the understanding what may be, and what may not be given, or required in a Spheric Triangle; and having already given you the several Definitions of a Sphere, and the Circles of it, with the Kinds of Triangles, which I will not here repeat, I pass on to the *Affections of Spheric Triangles*, as follow.

1. Every Side of a Spheric Triangle is an Arch of a Great Circle, and is less than a Semi-circle.

2. Every Great Circle divides the Sphere or Globe, into two equal Parts or Hemispheres.

3. Any two Great Circles cutting each other, the Angles which are opposite and contrary, are equal to one another.

4. The Sum of any two Sides (of a Triangle) is greater than the third Side.

5. The Sum of the three $\left\{ \begin{array}{l} \text{Sides} \\ \text{Angles} \end{array} \right\}$ is less than $\left\{ \begin{array}{l} 360d. \\ 540d. \end{array} \right.$ but more than 180d.

6. Any two Sides added together, their Sum is less than the Difference between the third Side and 180d. But,

Any two Angles added together, their Sum is more than the Difference between the third Angle and 180d.

7. In a Rectangular Triangle, the Legs and their opposite Angles are of the same *Affection*; that is, if a Leg be more, or less than a Quadrant, its opposite Angle is likewise more, or less than a Right Angle.

8. In a Rectangular Triangle, if one Leg be a Quadrant, the Hypotenuse shall be a Quadrant; but if both Legs be of the same *Affection*, the Hypotenuse is less than a Quadrant; if of different, 'tis more, and the contrary; that is, if each of the Legs be less, or more than 90d. the Hypotenuse is less than 90d. But if one Leg be more than 90d. and the other less, the Hypotenuse is more than 90d.

9. If the Hypotenuse be $\left\{ \begin{array}{l} \text{less} \\ \text{more} \end{array} \right\}$ than 90d. one Leg, and its opposite Angle will be $\left\{ \begin{array}{l} \text{less than 90d. the other may, or not.} \\ \text{more, and the other less than 90d.} \end{array} \right.$

10. If

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10. If both Angles at the Hypotenuse are Acute, or Obtuse, the Hypotenuse is less than a Quadrant; but if one be Acute, and the other Obtuse, the Hypotenuse is more than a Quadrant.

11. In every Triangle, greatest Sides are opposite to greatest Angles, and equal Sides to equal Angles.

12. In every Oblique Triangle, two $\left\{ \begin{array}{l} \text{Acute} \\ \text{Obtuse} \end{array} \right\}$ Angles being equal their opposite Sides are equal, and each $\left\{ \begin{array}{l} \text{less} \\ \text{more} \end{array} \right\}$ than a Quadrant

13. If two $\left\{ \begin{array}{l} \text{Acute} \\ \text{Obtuse} \end{array} \right\}$ Angles are unequal, the Side opposite to the $\left\{ \begin{array}{l} \text{lesser} \\ \text{greater} \end{array} \right\}$ Angle, shall be $\left\{ \begin{array}{l} \text{less} \\ \text{more} \end{array} \right\}$ than a Quadrant.

14. All the Angles Acute, each Side is less than a Quadrant.

These Things being premised, their Solution followeth; and first of *Rectangle Spheric Triangles*, in which are 16 Cases; and then *Oblique-angled Spheric Triangles*, in which are 12 Cases.

Section IV. The Solution of the 16 Cases of Rectangular Spheric Triangles, by the Lord Napier's Catholic Proposition.

1. **I**N a Rectangular Triangle, there are (besides the Right-angle) five Things, which the Lord Napier calleth the Five circular Parts of a Spheric Triangle, amongst which, the Right-angle being not reckon'd, the two Legs are supposed to join together.

2. Any one of these five circular Parts, may, (by Supposition,) be made a middle Part, and then the two circular Parts, which are next to that middle Part, are the Extreams Conjunct. And the other (two circular Parts) remote from that (assumed middle Part) are the Extreams Disjunct.

3. In every Case, two of the aforesaid five circular Parts, are (always) given, to find a third; of these three Things (two given and one required) one is middle Part, and the other two are Extreams, either Conjunct or Disjunct.

The Parts of a Rectangular Triangle being thus distinguished, observe the Universal Proposition following, invented by the aforesaid Lord, the Inventor of Logarithms.

The Catholic Proposition.

The Sine of a middle Part and Radius, are rectrocally proportional with the Tangent of the Extreams Conjunct; and, with the Sine Complement of the Extreams Disjunct. That is,

1. For the Extrems Conjunct, thus;

As the Radius, is to the Tangent of one Extream; so is the Tangent of the other, to the Sine of the middle Part. And,

2. For Extrems Disjunct, thus;

As the Radius, is to the Sine Complement of one Extream, so is the Sine Complement of the other, to the Sine of the middle Part. Therefore,

Note; When the middle Part is to be found, the Radius is to the 1st Term in the Proposition, as above: But if either of the Extrems be required, the other Extream must be the first Term. That is,

3. For Extrems Conjunct, thus;

As the Tangent of the given Extream, is to the Radius; so is the Sine of the middle Part, to the Tangent of the required Extream. And,

4. For Extrems Disjunct, thus;

As the Sine Complement of the given Extream, is to the Radius; so is the Sine of the Middle Part, to the Sine Complement of the required Extream. But,

Note 1. That if the middle Part, or either of the Extrems Conjunct be the Hypotenuse, or either of the Oblique Angles; instead of Sine, and of Tangent, you must use the Sine Complement, and Tangent Complement.

A TABLE of all the Varieties of Extrems
Conjunct, and Disjunct.

Number.	Middle Part.	Ext. Conjunct.	Ext. Disjunct.
1	Sine AB	Tang. — BC Tang. c. BAC	Sine AC B Sine A C
2	Sine c. BAC	Tang. c. — AC Tang. — AB	Sine c. BC Sine ACB
3	Sine c. AC	Tang. c. BAC Tang. c. ACB	Sine BC Sine AB
4	Sine c. ACB	Tang. c. — AC Tang. — BC	Sine BAC Sine c. AB
5	Sine BC	Tang. — AB Tang. c. ACB	Sine BAC Sine AC

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2. If either of the Extrems Disjunct be the Hypotenuse, or either of the Oblique Angles, instead of Sine Complement, you must use the Sine.

And for the easier understanding these Directions, observe the foregoing Table, wherein are placed the five Circular Parts of a Rectangle Spheric Triangle, under their respective Titles, whether they be taken for the middle Part, or for Extrems, either Conjunct or Disjunct; And unto those Parts are prefixed, Sine, Sine Complement, Tangent, and Tangent Complement; as they ought to be, and are used in the Cases following.

Problem 1. Case 1, 2 and 3. *The Hypotenuse, and one Leg, given;*

To find $\left\{ \begin{array}{l} 1. \\ 2. \\ 3. \end{array} \right\}$ The $\left\{ \begin{array}{l} \text{Angle adjacent} \\ \text{Angle opposite} \\ \text{Other Leg.} \end{array} \right\}$ to the given Leg.

Example. Plate 4. Fig. 1.

In the Rectangle Spheric Triangle *ABC*, there is given,

The $\left\{ \begin{array}{l} \text{Hypot. } AC \text{ 54d. 25m.} \\ \text{Leg } BC \text{ 23d. 30m.} \end{array} \right\}$ *ACB; BAC* } required?

This Triangle is made by Problem 10. of *Spheric Trigonometry Geometric*, in pages 123 and 124.

1. For the contained Angle *ACB*, or Angle adjacent to the given Leg, the Proportion is;

As the Radius, is to the Tangent of the given Leg; so is the Tangent Complement of the Hypotenuse, to the Sine Complement of the adjacent Angle required. Or thus,

Radius .. T. Leg *BC* :: T. c. Hypot *AC* .. S. c. Angle *ACB*.
T. 45d. .. T. 23d. 30m. :: T. 35d. 35m. .. S. 18d. 06m.
which subtract from 90d. rests 71d. 54m. for the Angle *ACB*.

Therefore the Extent (on the *Gunter's Scale*) from Tangent of 45d. to Tangent of 23d. 30m. reacheth from Tangent 35d. 35m. to the Tangent 17d. 15m. against which, on the Line of Sines, is 18d. 06m. the 4th Term in the Proportion above.

Note, The Hyp. and given Leg $\left\{ \begin{array}{l} \text{each} \\ \text{one} \end{array} \right\}$ more $\left\{ \begin{array}{l} \text{or —} \\ \text{the other} \end{array} \right\}$ less than a Quadrant, or 90d. the required Angle is $\left\{ \begin{array}{l} \text{Acute.} \\ \text{Obtuse} \end{array} \right\}$

2. For the Angle *BAC* opposite to the given Leg, the Proportion is thus;

1. For the Extrems Conjunct, thus;

As the Radius, is to the Tangent of one Extream; so is the Tangent of the other, to the Sine of the middle Part. And,

2. For Extrems Disjunct, thus;

As the Radius, is to the Sine Complement of one Extream, so is the Sine Complement of the other, to the Sine of the middle Part. Therefore,

Note; When the middle Part is to be found, the Radius is to the 1st Term in the Proposition, as above: But if either of the Extrems be required, the other Extream must be the first Term. That is,

3. For Extrems Conjunct, thus;

As the Tangent of the given Extream, is to the Radius; so is the Sine of the middle Part, to the Tangent of the required Extream. And,

4. For Extrems Disjunct, thus;

As the Sine Complement of the given Extream, is to the Radius; so is the Sine of the Middle Part, to the Sine Complement of the required Extream. But,

Note 1. That if the middle Part, or either of the Extrems Conjunct be the Hypotenuse, or either of the Oblique Angles; instead of Sine, and of Tangent, you must use the Sine Complement, and Tangent Complement.

A TABLE of all the Varieties of Extrems
Conjunct, and Disjunct.

Number.	Middle Part.	Ext. Conjunct.	Ext. Disjunct.
1	Sine AB	Tang. — BC Tang. c. BAC	Sine AC B Sine A C
2	Sine c. BAC	Tang. c. — AC Tang. — AB	Sine c. BC Sine ACB
3	Sine c. AC	Tang. c. BAC Tang. c. ACB	Sine BC Sine AB
4	Sine c. ACB	Tang. c. — AC Tang. — BC	Sine BAC Sine c. AB
5	Sine BC	Tang. — AB Tang. c. ACB	Sine BAC Sine AC

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2. If either of the Extrems Disjunct be the Hypotenuse, or either of the Oblique Angles, instead of Sine Complement, you must use the Sine.

And for the easier understanding these Directions, observe the foregoing *Table*, wherein are placed the five Circular Parts of a Rectangle Spheric Triangle, under their respective Titles, whether they be taken for the middle Part, or for Extrems, either Conjunct or Disjunct; And unto those Parts are perfix'd, Sine, Sine Complement, Tangent, and Tangent Complement; as they ought to be, and are used in the *Cases* following.

Problem 1. Case 1, 2 and 3. *The Hypotenuse, and one Leg, given;*

To find $\left\{ \begin{array}{l} 1. \\ 2 \\ 3. \end{array} \right\}$ The $\left\{ \begin{array}{l} \text{Angle adjacent} \\ \text{Angle opposite} \\ \text{Other Leg.} \end{array} \right\}$ to the given Leg.

Example. *Plate 4. Fig. 1.*

In the Rectangle Spheric Triangle *ABC*, there is given,

The $\left\{ \begin{array}{l} \text{Hypot. } AC \text{ 54d. 25m.} \\ \text{Leg } BC \text{ 23d. 30m.} \end{array} \right\}$ $\left\{ \begin{array}{l} ACB, \\ \text{and } AB \end{array} \right\}$ *BAC* } required?

This Triangle is made by *Problem 10. of Spheric Trigonometry Geometric, in pages 123 and 124.*

1. For the contained Angle *ACB*, or Angle adjacent to the given Leg, the Proportion is;

As the Radius, is to the Tangent of the given Leg; so is the Tangent Complement of the Hypotenuse, to the Sine Complement of the adjacent Angle required. Or thus,
Radius .. T. Leg *BC* :: T. c. Hypot *AC* .. S. c. Angle *ACB*.
T. 45d. .. T. 23d. 30m. :: T. 35d. 35m. .. S. 18d. 06m.
which subtract from 90d. rests 71d. 54m. for the Angle *ACB*.

Therefore the Extent (on the *Gunter's Scale*) from Tangent of 45d. to Tangent of 23d. 30m. reacheth from Tangent 35d. 35m. to the Tangent 17d. 15m. against which, on the Line of Sines, is 18d. 06m. the 4th Term in the Proportion above.

Note, The *Hyp.* and given Leg $\left\{ \begin{array}{l} \text{each} \\ \text{one} \end{array} \right\}$ more $\left\{ \begin{array}{l} \text{or —} \\ \text{the other} \end{array} \right\}$ less than a Quadrant, or 90d. the required Angle is $\left\{ \begin{array}{l} \text{Acute.} \\ \text{Obtuse} \end{array} \right\}$

2. For the Angle *BAC* opposite to the given Leg, the Proportion is thus;

As the Sine of the Hypotenuse, is to Radius; so is the Sine of the given Leg, to the Sine of its opposite Angle. Or thus,

S. Hypot. AC .. Radius :: S. Leg BC .. S. Angle BAC.

S. 54d. 25m. .. S. 90d. :: 23d. 30m. .. Sine 29d. 30m.

Therefore the Extent (on the *Gunter*) from Sine 54d. 25m. to Sine of 90d. reacheth from Sine of 23d. 30m. to Sine of 29d. 30m. the fourth Term in the Proportion abovesaid.

Note; The given Leg $\left\{ \begin{array}{l} \text{less} \\ \text{more} \end{array} \right\}$ than a Quadrant, or 90d.

the required Angle is $\left\{ \begin{array}{l} \text{Acute.} \\ \text{Obtuse.} \end{array} \right\}$

3. For the Leg AB, the Proportion is thus;

As the Sine Complement of the given Leg, is to Radius; so is the Sine Complement of the Hypotenuse, to the Sine Complement of the required Leg. Or thus,

S. c. Leg BC .. Radius :: S. c. Hyp. AC .. S. c. Leg AB.

S. 66d. 30m. .. S. 90d. :: S. 35d. 35m. .. S. 39d. 35m.

which subtract from 90d. resteth 50d. 25m. for the Leg AB required.

Therefore the Extent (on the *Gunter's Scale*) from the Sine of 66d. 30m. to Sine of 90d. will reach from Sine of 35d. 35m. to Sine of 39d. 35m. the fourth Term in the Proportion abovesaid.

Note; The Hypot. and given Leg of $\left\{ \begin{array}{l} \text{one} \\ \text{a different} \end{array} \right\}$ Kind,

the required Leg is $\left\{ \begin{array}{l} \text{less} \\ \text{more} \end{array} \right\}$ than a Quadrant

Problem 2. Case 4, 5, and 6.

The Hypotenuse, and one Angle given;

To find $\left\{ \begin{array}{l} 1. \\ 2. \\ 3. \end{array} \right\}$ the $\left\{ \begin{array}{l} \text{Leg opposite} \\ \text{Leg adjacent} \\ \text{other Angle.} \end{array} \right\}$ to the given Angle;

Example. *Plate 4. Fig. 2.*

In the Rectangle Spheric Triangle ABC, there is given,

To find $\left\{ \begin{array}{l} \text{Hypot. AC 54d. 25m.} \\ \text{Angle BAC 29d. 30m.} \end{array} \right\}$ $\left\{ \begin{array}{l} \text{Leg BC, AB, and} \\ \text{Angle ACB required?} \end{array} \right\}$

This Triangle is made by Problem 11. of *Spheric Trigonometry Geometric*, in pages 124 and 125.

1. For the Leg BC, opposite to the given Angle, the Proportion is thus:

As Radius, is to the Sine of the Hypotenuse; so is the Sine of the given Angle, to the Sine of it's opposite Leg required. Or thus.

Radius

Radius .. S. Hypot. AC :: S. Angle BAC .. S. Leg BC.
 S. 90d. .. S. 54d. 25m. :: S. 29d. 30m. .. S. 23d. 30m.

Note; The given Angle $\left\{ \begin{array}{l} \text{Acute} \\ \text{Obtuse} \end{array} \right\}$ the required

Leg is $\left\{ \begin{array}{l} \text{less} \\ \text{more} \end{array} \right\}$ than a Quadrant.

2. For the Leg AB, adjacent to the given Angle, the Proportion is this;

As the Tangent Complement of the Hypotenuse, is to Radius; so is the Sine Complement of the given Angle, to the Tangent of its adjacent Leg. Or,

As Radius, is to the Sine Complement of the given Angle; so is the Tangent of the Hypotenuse, to the Tangent of the Leg required. That is,

Radius. .. S. c. BAC :: T. Hypot. AC .. T. Leg AB.
 S. 90d. .. S. 60d. 30m. :: T. 54d. 25m. .. T. 50d. 30m.

Note; When each given Thing is less, or more than 90d. the required Leg is less than a Quadrant; but if one is less, and the other more, the required Leg is more than a Quadrant.

3. For the Angle ACB, the Proportion is this;

As the Tangent Complement of the given Angle, is to Radius; so is the Sine Complement of the Hypotenuse, to the Tangent Complement of the other Angle. Or thus,

As Radius, is to the Sine Complement of the Hypotenuse; so is the Tangent of the given Angle, to the Tangent Complement of the Angle required. That is;

Radius .. S. c. Hypot. AC :: T. Angle BAC .. T. c. Angle ACB.
 S. 90d. .. S. 35d. 35m. :: T. 29d. 30m. .. T. 18d. 10m.
 which subtract from 90d. rests 71d. 50m. for the Angle ACB.

Note; When each given Thing is less, or more than 90d. the required Angle is Acute; but when one is more, and the other less, 'tis Obtuse.

Problem 3. Cases 7, 8, 9. *A Leg and it's adjacent Angle given;*

To find $\left\{ \begin{array}{l} 1. \\ 2. \\ 3. \end{array} \right\}$ The $\left\{ \begin{array}{l} \text{Leg} \\ \text{Angle} \\ \text{Hypotenuse} \end{array} \right\}$ opposite to the given $\left\{ \begin{array}{l} \text{Angle} \\ \text{Leg} \end{array} \right\}$.

Example. Plate 4. Fig. 3.

In the Rectangle Triangle ABC, Right-angled at B, there is given $\left\{ \begin{array}{l} \text{Leg—AB 50d. 30m.} \\ \text{Angle BAC 29d. 30m.} \end{array} \right\}$ Leg BC, Angle ACB. and Hypot. AC required ?

This

This Triangle is made by *Problem 12. of Spheric Trigonometry Geometric*, in *pages 125 and 126.*

1. For the Leg *BC* opposite to the given Angle, the Proportion is,

As the Tangent Complement of the given Angle, is to the Radius ; so is the Sine of its adjacent Leg, to the Tangent of its opposite Leg required. Or thus ;

As the Radius, is to the Sine of the given Leg ; so is the Tangent of its adjacent Angle, to the Tangent of its opposite Leg. That is,

Radius .. S. Leg *AB* :: T. Angle *BAC* .. T. Leg *BC*.
S. 90d. .. S. 50d. 30m. :: T. 29d. 30m. .. T. 23d. 35m.

Note ; The given Angle Acute, the required Leg is less than a Quadrant, but when Obtuse, then more than a Quadrant.

2. For the Angle *ACB*, opposite to the given Leg, the Proportion is ;

As Radius, is to the Sine Complement of the given Leg ; so is the Sine of its adjacent Angle, to the Sine Complement of its opposite Angle required. That is,

Radius .. S.c. Leg *AB* :: S. Angle *BAC* .. S. c. Angle *ACB*.
S. 90d. .. S. 39d. 30m. :: S. 29d. 30m. .. S. 18d. 12m.
whose Complement 71d. 48m. is the Angle *ACB*.

Note ; The given Leg less, or more than 90d. the Angle required is Acute, or Obtuse accordingly.

3. For the Hypotenuse, the Proportion is ;

As the Tangent of the given Leg, is to the Radius ; so is the Sine Complement of its adjacent Angle, to the Tangent Complement of the required Hypotenuse. Or thus,

As the Radius, is to the Sine Complement of the given Angle ; so is the Tangent Complement of its adjacent Leg, to the Tangent Complement of the Hypotenuse. That is,

Radius .. S.c. Angle *BAC* :: T.c. .. Leg *AB* .. T.c. Hyp. *AC*.
S. 90d. .. S. 60d. .. 30m. :: T. 39d. 30m. .. T. 35d. 18m.
whose Complement 54d. 22m. is the Hypotenuse *AC*.

Note ; When each Thing is less, or more than 90d. the Hypotenuse is less than a Quadrant ; but if one is less, and the other more, then the Hypotenuse is more than a Quadrant.

Prob. 4. Case 10, 11, 12. *A Leg, and its opposite Angle given ;*

To find $\left. \begin{array}{l} 1. \\ 2. \\ 3. \end{array} \right\} \text{the} \left\{ \begin{array}{l} \text{Leg} \\ \text{Angle} \\ \text{Hypotenuse.} \end{array} \right\} \text{adjacent to the given} \left\{ \begin{array}{l} \text{Angle.} \\ \text{Leg.} \end{array} \right.$ Example.

Example. *Plate 4. Fig. 4.*

In the Rectangle Spheric Triangle ABC, there is,
 given { Leg — BC 23d. 30m. } Leg AB, Angle ACB, and
 { Angle BAC 29d. 30m. } Hypotenuse AC required.

This Triangle is made by Problem 13, of Spheric Trigonometry Geometric, in page 126.

1. For the Leg AB, adjacent to the given Angle, the Proportion is this;

As Radius, is to the Tangent of the given Leg; so is the Tangent Complement of its opposite Angle, to the Sine of the other Leg required. That is,

Radius .. T. Leg BC :: T. c. Angle BAC .. S. Leg AB.

T. 45d. .. T. 23d. 30m. :: T. 60d. 30m. .. S. 50d. 25m.

Note, If the unknown Angle be Acute, or Obtuse, the required Leg accordingly is less, or more than a Quadrant.

Or, The Hypotenuse and given Leg, each less, or more than 90d. the required Leg is less than a Quadrant; but if one is more, and the other less, 'tis more than a Quadrant.

2. For the Angle ACB adjacent to the given Leg, the Proportion is this;

As the Sine Complement of the given Leg, is to the Radius; so is the Sine Complement of its opposite Angle, to the Sine of its adjacent Angle. That is,

S. c. Leg BC .. Radius :: S. c. Angle BAC .. S. Angle ACB.

S. 66d. 30m. .. S. 90d. :: S. 60d. 30m. .. S. 71d. 48m.

Note; If the Hypotenuse and given Angle be each less, or more than 90d. the Angle required is Acute; but when one is more, and the other less, 'tis Obtuse.

Or, the Leg adjacent to the given Angle being less, or more than 90d. accordingly the Angle required is Acute or Obtuse.

3. For the Hypotenuse AC, the Proportion is this:

As the Sine of the given Angle, is to the Radius; so is the Sine of its opposite Leg, to the Sine of the Hypotenuse required. That is,

S. Angle BAC .. Radius :: S. Leg BC .. S. Hypotenuse AC.

S. 29d. 30m. .. S. 90d. :: S. 23d. 30m. .. S. 54d. 20m.

Note; If both Legs, or both Angles are of one Kind, the Hypotenuse is less than a Quadrant, but if they be of different Kinds, the Hypotenuse is more than a Quadrant.

Problem 5. Case 13 and 14. Both the Legs given; to find

1. Either of the Angles? 2. The Hypotenuse?

Example.

Example. Plate 4. Fig. 5.

In the Rectangle Spheric Triangle ABC, there is given, Leg $\left\{ \begin{array}{l} AB \text{ 50d. 30m.} \\ BC \text{ 23d. 30m.} \end{array} \right\}$ Angle BAC, or ACB, and Hypotenuse AC required.

This Triangle is made by Prob. 14. of Spheric Trigonometry Geometric, in page 125.

1. For either of the Angles, the Proportion is;

As the Tangent of one Leg, is to Radius; so is the Sine of the other Leg, to the Tangent Complement of the Angle opposite to the first Leg. Or thus,

As Radius, is to the Sine of one Leg; so is the Tangent Complement of the other Leg, to the Tangent Complement of the Angle opposite to the last Leg. That is,

Radius .. S. Leg AB :: T.c. Leg BC .. T.c. Angle BAC.

S. 90d. .. T. 50d. 30m. :: T. 66d. 30m. .. T. 60d. 35m. whose Complement 29d. 25m. is the Angle BAC: Also it is,

Radius .. S. Leg BC :: T. c. Leg AB .. T. c. Angle ACB.

S. 90d. .. S. 23d. 30m. :: T. 39d. 30m. .. T. 18d. 15m. whose Complement 71d. 45m. is the Angle ACB.

Note; If the Leg opposite to the required Angle be less than a Quadrant, the Angle sought is Acute; but if greater, then 'tis Obtuse.

2. For the Hypotenuse, the Proportion is thus;

As Radius, is to the Sine Complement of one Leg; so is the Sine Complement of the other Leg, to the Sine Complement of the Hypotenuse. That is,

Radius .. S. c. Leg AB :: S. c. Leg BC .. S. c. Hypot. AC.

S. 90d. .. S. 39d. 30m. :: S. 66d. 30m. .. S. 35d. 40m. whose Complement 54d. 20m. is the Hypotenuse AC.

Note; If both Legs be of one Kind, the Hypotenuse is less than a Quadrant; but when of different Kinds (that is one Leg more, the other less than a Quadrant) then the Hypotenuse is more than a Quadrant.

Problem 6. Case 15 and 16. Both the Oblique Angles given; To find, 1. Either of the Legs? 2. The Hypotenuse?

Example. Plate 4. Fig. 6.

In the Rectangle Triangle ABC, Right-angled at B, is given, Angle $\left\{ \begin{array}{l} BAC \text{ 29d. 30m.} \\ ACB \text{ 71d. 56m.} \end{array} \right\}$ Leg AB, or BC, and Hypotenuse AC required?

This Triangle is made by Problem 15, of Spheric Trigonometry Geometric, in page 128.

1. For either of the Legs, the Proportion is thus;

As

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As the Sine of one Angle, is to Radius ; so the Sine Complement of the other Angle, to the Sine Complement of its opposite Leg. That is,

S. Angle BAC .. Radius : : S.c. Angle ACB .. S. c. Leg AB.
 S. 29d. 30m. .. S. 90d. : : S. 18d. 04m. .. S. 40d. 45m.
 whose Complement 49d. 15m. is the Leg AB : Also it is,
 S. Angle ACB .. Radius : : S.c. Angle BAC .. S. c. Leg BC.
 S. 71d. 56m. .. S. 90d. : : S. 60d. 30m. .. S. 66d. 30m.
 whose Complement 23d. 30m. is the Leg BC.

Note ; If the Angle opposite to the required Leg be Acute, the Leg sought is less than a Quadrant ; but if Obtuse, then 'tis greater than a Quadrant.

2. For the Hypotenuse, the Proportion is thus ;

As Radius, is to the Tangent Complement of one Angle ; so is the Tangent Complement of the other Angle, to the Sine Complement of the Hypotenuse. That is,
 Radius .. T. c. Angle BAC : : T. c. Angle ACB .. S. c. Hyp. AC.
 T. 45d. .. T. 60d. 30m. : : T. 18d. 04m. .. S. 35d. 35m.
 whose Complement 54d. 25m. is the Hypotenuse AC.

Note ; The Angles of one Kind, the Hypotenuse is less than a Quadrant ; but when of different Kinds, 'tis more than a Quadrant.

Section V. *Four Axioms, by which the 12 Cases of Oblique-angled Spheric Triangles are solved.*

Axiom 1. **I**N all Spheric Triangles, the Sines of their Sides are in direct Proportion to the Sines of their opposite Angles. That is,

1. As the Sine of a Side, is to the Sine of its opposite Angle ; so is the Sine of another Side, to the Sine of its opposite Angle.

2. As the Sine of an Angle, is to the Sine of its opposite Side ; so is the Sine of another Angle, to the Sine of its opposite Side.

Axiom 2. *First*, As the Sine of half the Sum of two Sides, (containing an Angle) is to the Sine of half their Difference ; So is the Tangent Complement of half the contained Angle, to the Tangent of half the Difference of the other two Angles.

Again,

Secondly, As the Sine Complement of half the Sum of two Sides (containing an Angle) is to the Sine Complement of half their Difference ;

So is the Tangent Complement of half the contain'd Angle, to the Tangent of half the Sum of the other two Angles.

Axiom 3. *First*, As the Sine of half the Sum of two Angles, is to the Sine of half their Difference ; So

So is the Tangent of half their interjacent Side, to the Tangent of half the Difference of the other two Sides. Again,

Secondly, As the Sine Complement of half the Sum of two Angles, is to the Sine Complement of half their Difference ;

So is the Tangent of half their interjacent Side, to the Tangent of half the Sum of the other two Sides.

Axiom 4. As the Rectangle of the Sines of the two containing Sides, is to the Square of the Radius.

So is the Rectangle of the Sines of half the Sum of the three Sides, and of the Difference of the Side opposite thereunto, to the Square of the Sine Complement of half the contained Angle sought.

The Explanation and Use of these four Axioms, you will find in the Solution of the following *Cases* of Oblique Spheric Triangles.

Problem 7. *Case 1, 2. and 3.*

Two Sides, and an opposite Angle given ; to find

1. The Angle opposite to the other Side,
 2. The Angle contained between them, } if the required
 3. The third Side ————— }
- opposite Angle be foreknown to be Acute, or Obtuse.

Example. *Plate 4. Fig. 7.*

In the Oblique Spheric Triangle ACD, there is given

{	Side	AC 34d. 07m.	{	Angle ACD being Obtuse	} req.
	Side	AD 65d. 20m.		Angle CAD —————	
	Angle ADC 27d. 30m.	Side		CD —————	

This Triangle is made by Prob. 16. of *Spheric Trigonometry Geometric*, in pages 128 and 129.

1. For the opposite Angle ACD, the Proportion (by *Axiom 1.*) is thus ;

As the Sine of the Side AC, is to the Sine of the Angle ADC ; so is the Sine of the Side AD, to the Sine of the Angle ACD ; That is,

S. Side AC .. S. Angle ADC : : S. Side AD .. S. Angle ACD
S. 34d. 07m. .. S. 27d. 30m. : : S. 65d. 20m .. S. 48d. 25m.

Which subtract from 180d. resteth 131d. 35m. for the Angle ACD, it being required to be Obtuse.

2. For the contained Angle CAD (having before found the opposite Angle) the Proportion (by *Axiom 2. Part 1.*) inverted, is thus ;

As the Sine of half the Difference of the Sides AD, and AC, is to the Sine of half their Sum ; so is the Tangent of half the Difference of the Angles ACD, and ADC, to the Tangent Complement of half the Angle CAD. And,

3. For

3. For the third Side CD, (having found the opposite Angle) the Proportion, (by *Axiom 3. Part 1.*) inverted, is thus ;

As the Sine of half the Difference of the Angles ACD, and ADC, is to the Sine of half their Sum :

So is the Tangent of half the Difference of the Sides AD and AC, to the Tangent of half the Side CD. That is,

d. m.		d. m.		d. m.
Side AD 65.20		Ang. ACD 131.35		
Side AC 34.07	d. m.	Ang. ADC 27.30		d. m.
Sum is 99.27	$\left\{ \frac{1}{2} \right\}$	Sum is 159.05	$\left\{ \frac{1}{2} \right\}$	Sum 79.32
Differ 31.13	$\left\{ \frac{1}{2} \right\}$	Differ. is 104.05	$\left\{ \frac{1}{2} \right\}$	Differ. 52.02
S. $\frac{1}{2}$ Diff. Sides .. S. their Sum :: T. $\frac{1}{2}$ Diff. Ang. .. T.c. $\frac{1}{2}$ CAD				
S. 15d. 36m. .. S. 49d. 43m. :: T. 52d. 02m. .. T. 74d. 40m.				
Which subtract from				90d. 00m.
Remainder is half the Angle CAD				15d. 20m.
Which being doubled				30d. 40m.
Produceth the required Angle CAD				
S. $\frac{1}{2}$ Diff. Ang. .. S. $\frac{1}{2}$ their Sum :: T. $\frac{1}{2}$ Diff. Sides .. T. $\frac{1}{2}$ CD.				
S. 52d. 02m. .. S. 79d. 32m. :: T. 15d. 36m. .. T. 19d. 12m.				
Which being doubled				38d. 24m.
Produceth the required Side CD				

Problem 8. Case 4, 5, and 6.

Two Angles, and one Side opposite given ; to find

1. The Side opposite to the other Angle,
 2. The interjacent, or Side between them
 3. The third Angle
- if the required opposite Side be foreknown to be more, or less than a Quadrant.

Example. Plate 4. Fig. 8.

In the Oblique Spheric Triangle ACD, there is given,

Angle CAD 30d. 48m.	Side AC less than 90d.	} required?
Angle ADC 27d. 30m.	Side AD	
Side CD 38d. 28m.	Angle ACD	

This Triangle is made by Problem 17. of Spheric Trigonometry Geometric, in page 129.

1. For the opposite Side AC, the Proportion by *Ax. 1.* is thus ;
As the Sine of the Angle CAD, is to the Sine of the Side CD ;
so is the Sine of the Angle ADC, to the Sine of the Side AC.
That is,

S. Angle CAD .. S. Side CD :: S. Angle ADC .. S. Side AC req.
S. 30d. 48m. .. S. 38d. 28m. :: S. 27d. 30m. .. S. 34d. 06m.

2. For the interjacent Side AD, (having first found the opposite Side) the Proportion, (by *Axiom 3. Part 1.*) inverted, is thus ;

As

As the Sine of half the Difference of the Angles CAD and ADC, is to the Sine of half their Sum;

So is the Tangent of half the Difference of the Sides CD and AC, to the Tangent of half the Side AD. And,

3. For the third Angle ACD, (having first found the opposite Side) the Proportion, (by *Axiom 2. Part 1.* inverted) is thus;

As the Sine of half the Difference of the Sides CD and AC, is to the Sine of half their Sum;

So is the Tangent of half the Difference of the Angles CAD and ADC, to the Tangent Complement of half the Angle ACD. This is,

	d. m.		d. m.		d. m.
Ang. } CAD	30.48.	Side { CD	38.28		
ADC	27.30.	AC	34.06		
Sum is	58.18.	Sum 29.09	Sum is 72.34	{	Sum 36.17
Difference	03.18.	Diff. 01.39	Diff. is 04.22	{	Diff 02.11
S. half Diff. Angles ..	S. half their Sum ::	T. half Diff. Sides ..	T. $\frac{1}{2}$ AD		
S. 01d. 39m. ..	S. 29d. 09m. ::	T. 02d. 11m. ..	T. 32d. 38m.		
Which being doubled			32d. 38m.		
Produceth the interjacent Side AD			65d. 16m.		
S. $\frac{1}{2}$ Diff. Sides ..	S. $\frac{1}{2}$ their Sum ::	T. $\frac{1}{2}$ Diff. Angles ..	T. c. $\frac{1}{2}$ ACD.		
S. 02d. 11m. ..	S. 36d. 17m. ::	T. 01d. 39m. ..	T. 24d. 14m.		
Which subtract from			90d. 00m.		
Remainder is half the Angle ACD			65d. 46m.		
Which being doubled			65d. 46m.		
Produceth the Angle ACD to be			131d. 32m.		

Note; In the six preceding Cases, the three given Terms, without the Quality of a Fourth, are not sufficient, whereby one single Answer may be found; and the Quality of the Fourth is not always discoverable by the given Terms: Therefore they are called the *Six doubtful Cases*.

Problem 9. Case 7, and 8.

Two Sides, and one Angle between them given; to find

1. *Either of the other Angles;*
2. *The third Side, or Side opposite to the given Angle.*

Example Plate 4. Fig. 9.

In the Oblique Spheric Triangle ACD, there is

given {	Side	AC 34d. 06m.	{ Angle ACD, or } { Angle ADC, and } { Side C D is — } required?
	Side	AD 65d. 20m.	
	Angle	CAD 30d. 46m.	

This

This Triangle is made by *Problem 18. of Spheric Trigonometry Geometric*, in Pages 129 and 130.

For the Angle ACD, or ADC, the Proportion (by *Axiom 2. Parts 1 and 2.*) is thus ;

	d. m.		d. m.				d. m.
Side {	AD	65.20	Angle CAD	30.46			
	AC	34.06	The half is	15.23	} its Comp. {	74.37	
Sum of Sides		99.26	} The ½ {	Sum 49.43		40.17	
Differ. Sides		31.14		Diff. 15.37		74.23	
As S. ½ Sum AD & AC .. S. ½ Diff. : : T. c. ½ CAD .. T. ½ Diff. An.							
As S. 49d. 43m. .. S. 15d. 37m. : : T. 74d. 37m. .. T. 52d. 02m.							

Then again,

As S. c. ½ Sum sides .. S. c. ½ Diff. : : T. c. ½ CAD .. T. ½ Sum Angle

As S. 40d. 17m. .. S. 74d. 23m. : : T. 74d. 37m. .. T. 79d. 32m.

To it add the half Difference found above ————— 52d. 02m.

The Sum is the greater Angle ACD ————— 131d. 34m.

And being subtracted, is the less Angle ADC ————— 27d. 30m.

Note, If the Sum of the two containing Sides exceeds a Semicircle, then subtract each side from 180 Degrees, and proceed with those Remainders as with the Sides given ; the Proportion produces the Supplement of the Angle required to a Semicircle.

For the third Side CD, or Side opposite to the given Angle, the Proportion (after the work above is done) may be made by *Axiom 1.* Or it may be deduced from the *Lord Napier's Catholic Proposition* (by a supposed Perpendicular, let fall from one end of the less given Side, to the greater Side given, reducing the Oblique Triangle into two Rectangulars.) Which finds the Side opposite to the given Angle at two Proportions, without finding the Angles ; and it's thus,

1. As Radius, is to the Sine Complement of the contained Angle : So is the Tangent of the less given Side, to the Tangent of a Fourth Arch.

Then, if the contained Angle be Acute, subtract the Fourth Arch from the greater given Side, but when it is Obtuse from the Supplement thereof to a Semicircle, or 180 Degrees, the Remainder is called the *Residual Arch*. Then,

2. As the Sine Complement of the Fourth Arch, is to the Sine Complement of the *Residual Arch* ;

So is the Sine Complement of the less given Side, to the Sine Complement of the Side required. That is,
 As Radius .. S.c. Angle CAD : : T. Side AC .. T. Fourth Arch,
 As S. 90d. .. S. 59d. 54m. : : S. 34d. 06m. .. T. 30d. 12m.
 which being subtracted from the Side AD ——— 65d. 20m.

The Remainder is the Residual Arch ——— 35d. 08m.

Then,

As S.c. 4th Arch .. S. c. Resid. Arch : : S.c. Side AC .. S.c. Side CD.
 As S. 59d. 48m. .. S. 54d. 32m. : : 55d. 54m. .. S. 51d. 35m.
 whose Complement 38d. 25m. is the Side CD required.

Note, When the contained Angle, and Residual Arch, are each more, or less than 90 Degrees, the Side sought is less than a Quadrant; but when one is more, and the other less, 'tis more than a Quadrant.

Problem 10. Case 9, and 10.

Two Angles and one Side between them given;

To find $\left\{ \begin{array}{l} 1. \text{ Either of the other Sides?} \\ 2. \text{ The Angle opposite to the given Side?} \end{array} \right.$

Example. In the Oblique Spheric Triangle ACD, there is given

The $\left\{ \begin{array}{l} \text{Angle ACD } 131^{\circ} 34' \\ \text{Angle ADC } 27^{\circ} 30' \\ \text{Side CD } 38^{\circ} 28' \end{array} \right. \left\{ \begin{array}{l} \text{Side AC, or} \\ \text{Side AD, and} \\ \text{Angle CAD is} \end{array} \right. \text{ required?}$

This Triangle is made by Problem 19. of Spheric Trigonometry Geometric, in page 130. See Plate 4. Fig. 10.

For the Side AC, or AD, the Proportion (by Ax. 3. Part 1 and 2.) is thus; d. m.

Angle ACD	131.34		The Side CD	38.28	
Angle ADC	27.30		The half is	19.14	d. m.
Sum of Angles	159.04	}	The $\frac{1}{2}$	{ Sum 79.32 }	} its Com. { 10.28
Difference is	104.04			{ Diff. 52.02 }	
As S. $\frac{1}{2}$ Sum Ang.	.. S. $\frac{1}{2}$ their Dif.	:	T. $\frac{1}{2}$ Side CD	.. T. $\frac{1}{2}$ Dif. Sides	
As S. 79d. 32m.	.. S. 52d. 02m.	:	T. 19d. 14m.	.. T. 15d. 38m.	

Then again,

As S.c. $\frac{1}{2}$ Sum An. .. S. c. $\frac{1}{2}$ their Dif. : : T. $\frac{1}{2}$ Side CD .. $\frac{1}{2}$ Sum Sides.
 As S. 10d. 28m. .. S. 37d. 58m. : : T. 19d. 14m. .. T. 49d. 45m.

To it add the half Difference found above ——— 15d. 38m.

The Sum is the greater Side AD ——— 65d. 23m.

And being subtracted, is the less Side AC ——— 34d. 07m.

Note; If the Sum of the two given Angles exceed 180 Degrees, then subtract each given Angle from 180 Degrees, and proceed with those Remainders as with the Angles given; the Operation will produce each required Side's Supplement to a Semi-circle, or 180 Degrees.

For

For the Angle CAD, the Angle opposite to the given Side, the Proportion (after the Work above is done) may be by *Axiom* 1. Or from the *Catholic Proposition* (by a Perpendicular supposed to be let fall from the greater given Angle to its opposite Side) thus;

As Radius, is to the Sine Complement of the interjacent Side; so is the Tangent of the less given Angle, to the Tangent of a Fourth Arch.

Then, if the interjacent Side be more than a Quadrant, subtract the Fourth Arch from the greater given Angle; but when 'tis less, from the Supplement thereof to 180 Degrees, the Remainder is the Residual Arch. Then,

2. As the Sine Complement of the Fourth Arch, is to the Sine Complement of the Residual Arch;

So is the Sine Complement of the less given Angle, to the Sine Complement of the Angle required. That is,

As Radius .. S.c. Side CD :: T. Angle ADC .. T. 4th Arch

As S 90d. .. S. 51d. 32m. :: T. 27d. 30m. .. T. 22d. 10m.
which subtract from (Suppl. of the Angle ACD) 48d. 26m.

The Remainder is the Residual Arch ——— 26d. 16m.

Then,

S.c. 4th Arch .. S.c. Resid. Arch :: S.c. An. ADC .. S.c. An. CAD req
S 67d. 50m. .. S. 63d. 44m. :: S. 62d. 30m. .. S. 59d. 12m.
whose Complement 30d. 48m. is the Angle CAD required.

Note; When the adjacent Side, and Residual Arch are each more or less than 90d. the Angle sought is Acute; but when one is more, and the other less, 'tis Obtuse.

Problem 11. Case 11. *Three Sides given, to find any of the Angles;* Example. Plate 4. Fig. 11.

In the Oblique Spheric Triangle ACD there is given;

The Side $\left\{ \begin{array}{l} AD \ 65d. \ 20m. \\ CD \ 38d. \ 26m. \\ AC \ 34d. \ 08m. \end{array} \right\}$ Angle $\left\{ \begin{array}{l} ACD, \text{ or} \\ ADC, \text{ or} \\ CAD \text{ required?} \end{array} \right.$

This Triangle is made by Problem 20, of Spheric Trigonometry Geometric, in pages 130 and 131.

The Resolution of this, and the following Case depends upon the 4th *Axiom*; and for the more speedy Resolution, observe these following Directions, viz.

1. Add the three Sides together, and from their half Sum subtract the Side opposite to the Angle required, noting the Remainder.

K 2

2. To

2. To the Complement Arithmetic of the Logarithm Sines of the containing Sides, add the Logarithm Sines of the half Sum and the Remainder: Half the Total of these four Logarithms, is the Logarithm Sine of half the required Angle's Supplement to 180 Degrees.

The Operation for the Angle ACD, is thus ;

d. m.			
Side	{	CD 38 26	The containing Sides { S. co. ar. 0.206487 S. co. ar. 0.250944
	{	AC 34 08	
	{	AD 65 20	
Sum is	—	137 54	$\frac{1}{2}$ Sum Sides 68d. 57m. S. — 9.970006
Half Sum is	68	57	Remainder is — 3d. 37m. S. — 8.799897
Remain.	—	3 37	Sum of the four Logarithms is 19.227334
Double it		—	24d. 15m. S. $\frac{1}{2}$ Sum 9.613667
		—	24d. 15m.
The Sum is		—	48d. 30m.
Which subtract from		—	180d. 00m.

Remainder is the Angle ACD — 131d. 30m.

In like manner you may find any other Angle by Logarithms.

By Gunter's Scale say,

1. As Radius, is to the Sine of one of the containing Sides ;
So is the Sine of the other containing Side, to a Fourth Sine.

Then,

2. As that 4th Sine, is to the Sine of the half Sum of the Three Sides ; so is the Sine of the Remainder, to a Fifth Sine ;
against which on the Line of verfed Sines is the Angle required.

That is,

As Radius .. S. Side CD :: S. Side AC .. a Fourth Sine.

As S. 90d. .. S. 38d. 26m. :: S. 34d. 08m. .. S. 20d. 26m. Then,

As Fourth Sine .. S. half Sum Sides :: S. Remainder .. a Fifth Sine.

As S. 20d. 26m. .. S. 68d. 57m. :: S. 03d. 37m. .. S. 9d. 43m.
against which on the Line of Verfed Sines, is 131d. 30m. the Angle ACD as before.

Problem 12. Case 12. The Angles given ; to find a Side.

Example. Plate 4. Fig. 12.

In the Oblique Spheric Triangle ACD ; there is given,

The Angle { ACD 30d. 47m.
ADC 27d. 30m.
CAD 131d. 34m. } : The Side { CD, or
AC, or
AD, required ?

This Triangle is made by Problem 21. of Spheric Trigonometry Geometric, in Page 131.

This

This *Case* is likewise perform'd by the Directions in *Case 11*, the Angles being accounted Sides, and the Sides Angles; and then taking the Supplement of the greater (given) Angle to 180 Degrees.

For the Side AD, the Operation is thus;

	d. m.	
Sup. Ang CAD	48 26	} The adjacent Angles { S.co.ar. 0.125992
Angle { ADC	27 30	
Angle { ACD	30 47	
Sum is	106 43	} $\frac{1}{2}$ Sum Ang. 53d. 21m. S. — 9.904335
Half Sum is	53 21	
Remainder	22 34	Remainder 22d. 34m. S. — 9.584058
Double it		Sum of the four Logarithms is 19.949979
		70.45 S. half Sum 9.974989
		70.45
The Sum is		141.30 Which
Subtract from		180.00
Remainder is the Side AD	38.30	

In like manner may any other Side be found by Logarithms. Or thus,

By Gunter's Scale.

1. As Radius, to the Sine of one of the adjacent Angles (to the Side required); so is the Sine of the other adjacent Angle, to a Fourth Sine.

2. Then, as the Fourth Sine, is to the Sine of the half Sum of the three Angles; so is the Sine of the Remainder, to a fifth Sine: against which, on the Line of Versed Sines, is the Side required.

That is,

As Radius .. S. Sup. CAD: : S. Angle ADC .. a Fourth Sine.

As S. 90d. .. S. 48d. 26m. :: S. 27d. 30m. .. S. 20d. 13m.

Then again,

As Fourth Sine .. S. Sum $\frac{1}{2}$ Angles: : S. Remainder .. a Fifth Sine.

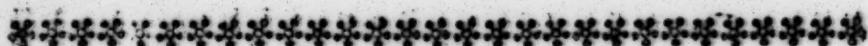
As S. 20d. 13m. .. S. 53d. 21m. :: S. 22d. 34m. .. S. 20d. 13m.

Against which, on the Line of Versed Sines, is — 38d. 30m. the Side AD, as above.

Note; When the greater Side (CD, which ever is opposite to the greater Angle) is required, the Operation will produce the Supplement thereof to a Semi-circle; wherefore, if it be subtracted from 180d. it leaves the Side sought: Or (by the

Logarithms) if you omit this Part of the Operation (which subtract from 180 Degrees, &c.) you have the Side required.

So much for the Doctrine of *Spheric Triangles*; the Application follows.



CHAPTER VI.

Containing the Description; and Use of the Globes.

HAVING finished *Spheric Trigonometry*, it remains to shew its Uses in *Geography*, *Great Circle-Sailing*, and *Astronomy*. In order to the perfect Understanding of these, it is requisite first to be acquainted with the Nature and Use of the Globes, which I will endeavour to perform briefly and plainly.

Section I. *The Description and Use of Globes in general.*

Definition 1. A *Globe*, (as to its Name and Figure) is so generally known, that 'tis needless here to produce a Mathematical Definition of it; but as to the Kinds of Material Globes, and their Parts, it's necessary something should be said.

2. The Kinds of Globes are two; *Terrestrial* and *Cælestial*, which together with their Appurtenances, are for the lively Representation of the Natural Situation, and Position of the Earth and Heavens, and are useful for the demonstrating (by Representation and Resolution of) any Problem belonging to the Sphere of Heaven, or Earth, either in *Geography*, *Navigation*, or *Astronomy*.

3. The Appurtenances appertaining to Material Globes are Six; the Body or Globe it self, Brazen Meridian, Quadrant of Altitude and its Screw, Hour-Circle and Index, Wooden Frame or Horizon, and Brass Semi-circle of Position; all may be used with either Globe; yet the last being of least Use, may be supplied by the Quadrant of Altitude.

4. The *Body*, or *Globe* it self, is an Emblem of Heaven, or of Earth; on which are drawn divers Lines and Circles, useful and proper for the Explication thereof.

5. The *Brazen Meridian*, is the Ring in which the Globe hangeth, and turneth upon its Axis, being two Wires issuing forth its Body; and is divided into four Quadrants, each 90 Degrees, and figured 10, 20, 30, &c. to 90.

6. The

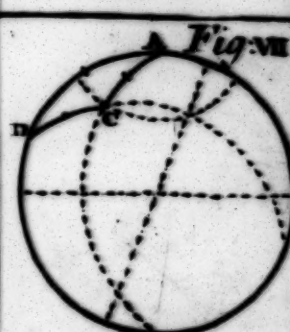
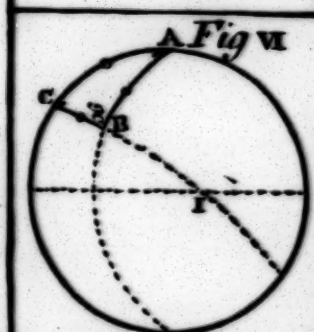
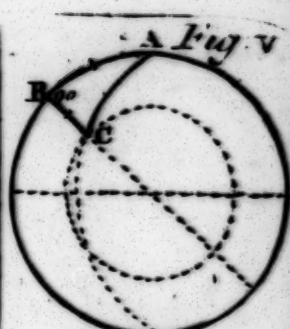
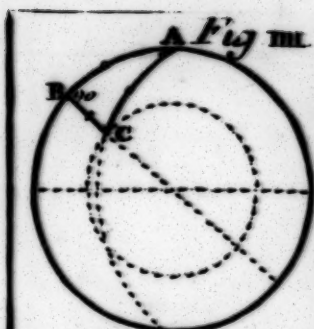
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III



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Plate 4 Fig 1

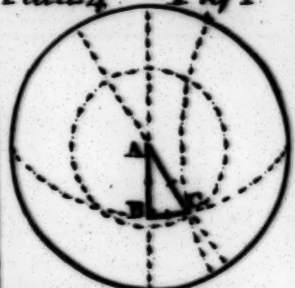


Plate 4 Fig 1.

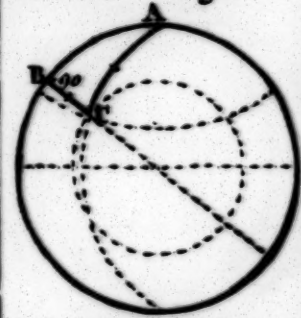


Fig 1

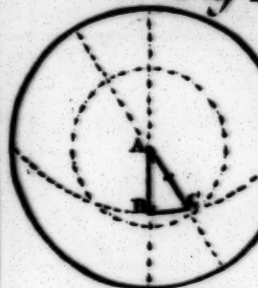
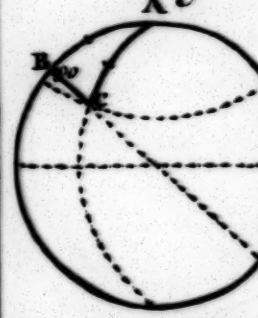
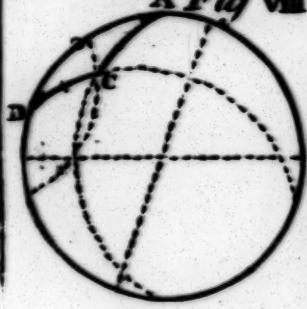


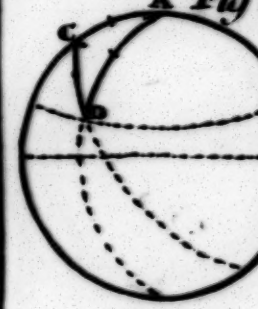
Fig 1

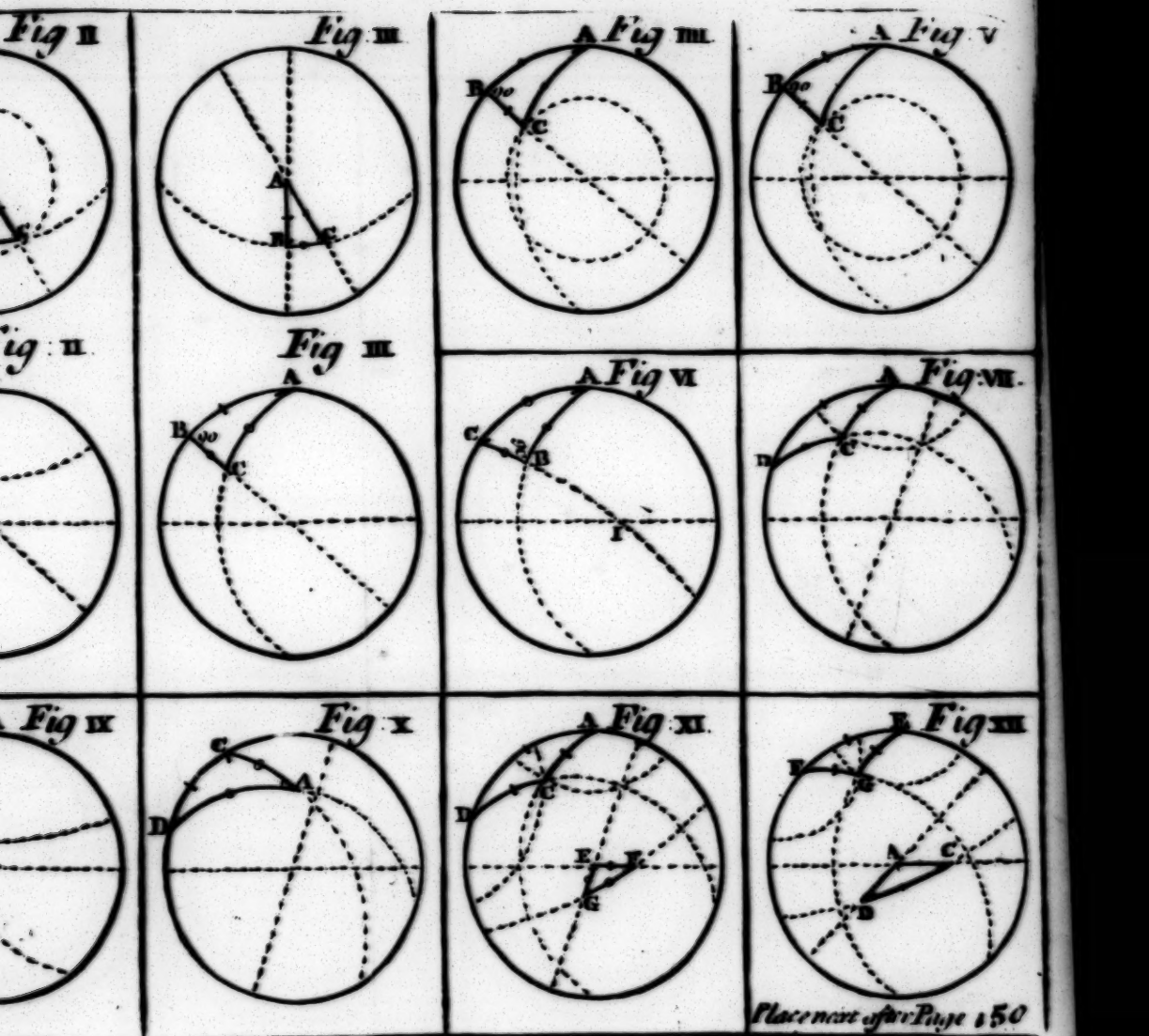


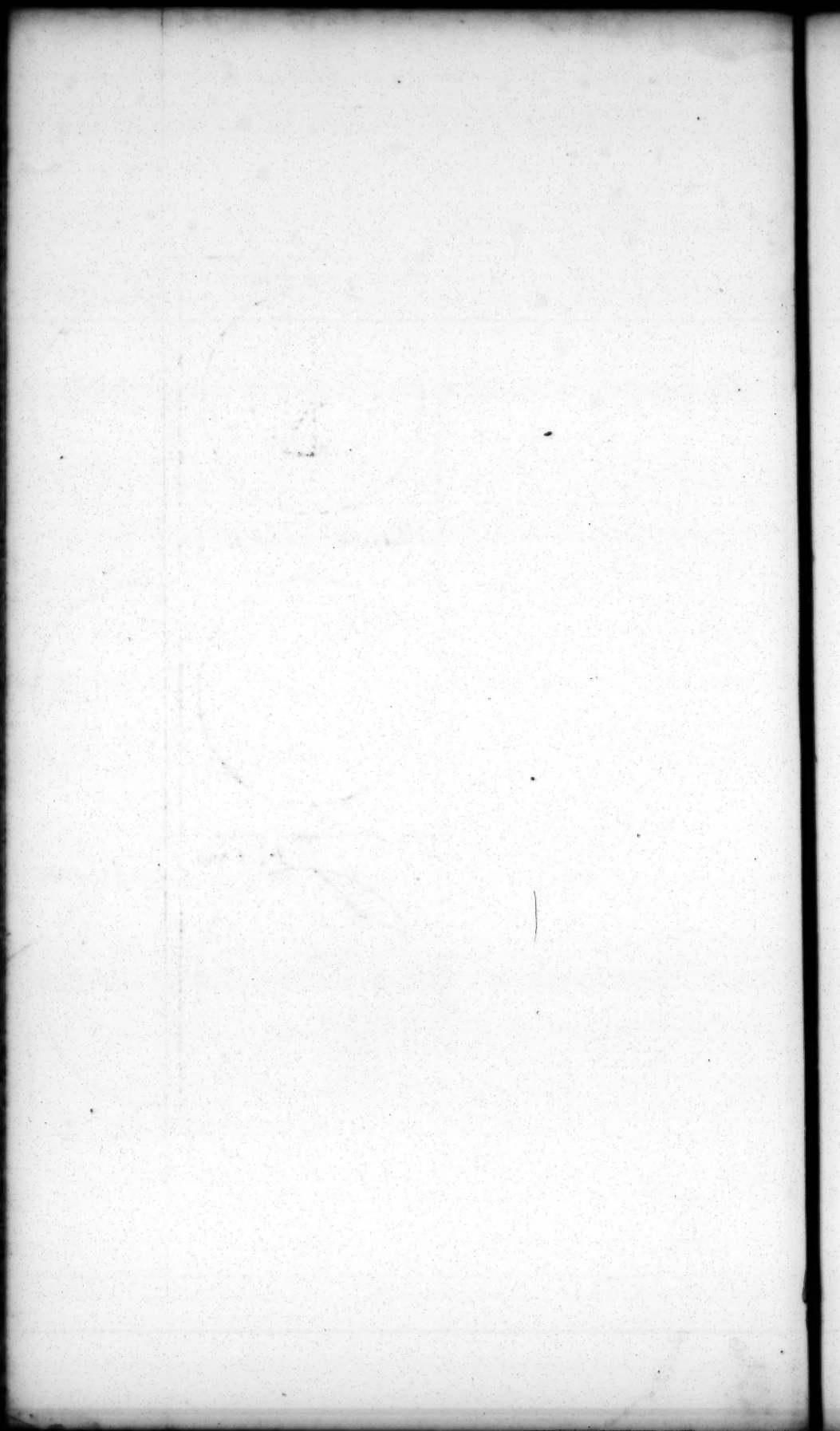
A Fig VII



A Fig







6. The *Quadrant of Altitude*, is a narrow thin Slip of Brass with a Notch, Nut, and Screw at one End; 'tis divided into 90d. which shews the Almicanter, or Circles of Altitude, and the Edge represents an Azimuth Circle.

7. The *Hour Circle*, is a flat Ring of Brass, so contrived, that it may be took off, and fixed about either Pole of the Globe; 'tis divided into 24 Hours of a Natural Day; each Hour is divided into Halves and Quartets; to this belongs an Index, having a round Hole at one End, to fix it on the Axis of the Globe.

8. The *Wooden Frame*, or *Horizon*, is round and flat, in which the Brazen Meridian doth move through two Notches, diametrically opposite, and another in the Middle of the Bottom of it: On the upper Part is a Kalendar, shewing the Day of the Month, Sun's Place in the Ecliptic, the Rumbs, or Points of the Compass, &c.

8. The *Semi-circle of Position*, is a Semi-circle of Brass; the upper Side is divided into 180 Degrees; it serveth to measure Distances, either on the Terrestrial or Cœlestial Globe.

Section II. *The Description and Use the Terrestrial Globe.*

THE *Terrestrial Globe*, hath on the Superficies of its Body, the whole Form and Fashion of the Earth and Sea, described; with the Circles of the Sphere, as Equator, Meridians, Tropics, &c.

In order to a clear Understanding the Use of this Globe, observe these following Geographic Definitions.

1. The *Earth*, together with the *Sea*, composeth that round Body called the *Orb*, or Globe of the Earth, which is described by Lines Real, and Imaginary.

2. The *Real Lines*, are such as agree to the Terrestrial Globe, by Nature, and so divide it into Continents, Islands and Seas: The Imaginary Parts, are such as are applied to it by vertue of our Understanding; and being not materially such, are supposed to be on the Earth: These Imaginary Lines are either streight or circular.

3. The *Axis*, is a streight Line imagined to pass through the Center of the Earth; the Extream Points are the Poles, on which the World is supposed to move; one called the Artic, or North Pole; the other the Antartic, or South Pole; 'tis represented by the Wires on which the Globe turneth.

4. The *circular Lines*, are either greater, as the Meridian, Horizon, *Æquator*; or less, as Tropics, Polar Circles, Parallels of Latitude,

5. *Meridian*, is a Circle passing through the Poles of the Earth, the Zenith and Nadir; crosseth the *Æquator* at Right Angles, and divideth the Earth into two equal Parts; one East, the other West. It is so called, because when the Sun cometh to the *Meridian* of any Place, 'tis then Noon; or Mid-day there; they are infinite in Number; for all Places from East to West have their several *Meridians*.

Of these one is called the First, or Chief *Meridian*, from which the Longitude of Places is reckon'd; 'tis of special Note and Use, but variously placed by Geographers: 'Tis represented on the *Globe* by a double Line passing through the Poles, and is divided into twice 90 Degrees, numbred from the *Æquator*, towards each Pole, ending in 90 Degrees.

6. The *Horizon*, is that Circle which comprehendeth all that Space of the Earth which is visible, and distinguisheth it from that (lying under the *Horizon*) which is invisible, 'tis either Sensible or Rational.

The *Sensible Horizon*, is that apparent Circle, which extends it self quite round about us, dividing the Heavens and Earth into two unequal Parts; and being limited by the Sight, is sometimes greater or less, according to the Condition of the Place, &c.

The *Rational Horizon*, is a Circle dividing the Heavens and Earth into two equal Parts, whose Poles are the Zenith and nadir. By this Circle our Days and Nights are measured, and the divers Risings and Settings of the Sun, Moon, and Stars, do appear: 'Tis represented on the *Globe* by the upper Part of the Wooden Frame.

Note; The *Meridian*, and *Horizon*, are moveable with the Mutation of Places.

7. The *Æquator*, is a Line under the Equinoctial in the Heavens, compassing the Earth in the Middle between its two Poles, dividing it into two equal Parts, called the Northern and Southern Hemispheres; from it, the Latitude of Places is reckon'd, either North or South: This Circle is represented on the *Globe* by a double, or treble Line; divided into 360 Degrees, and number'd 10, 20, 30, &c. from the Left-hand towards the Right, 'till it end in 360 Degrees.

This Circle is called *Æquator*, because when the Sun comes to it, which is twice a Year, (*viz.* about the 10th of *March*, at his Entrance into *Aries*; and again into *Libra*, about the 12th of *September*) he makes equal Days and Nights, throughout
the

the World. And upon it is writ in Capital Letters, *Linea sub Æquinoctiali.*

8. The *Left Circles*, described on Globes, are called Parallel Circles, some of which have particular Names, as *Tropics*, and *Polar Circles*.

9. The *Tropics* are two, being parallel to the Æquator, and Distance from it 23d. 29m. That on the North Side of it, is called the *Tropic of Cancer*, at which the Sun hath its greatest North Declination; then making to us (and all Places in North Latitude) the longest Day, and shortest Night; which is about the 11th of *June*: The other, on the South Side, is called the *Tropic of Capricorn*, at which the Sun hath his greatest South Declination, making then our shortest Day and longest Night, which is about the 12th of *December*. These *Tropics* have their Names thus; *Tropicus sub Cancro*, and *Tropicus sub Capricorno*.

10. The *Polar Circles* are two, being also parallel to the Æquator, and compassing the Poles of the World, at 23d. 29m. Distance: That about the North Pole is called the *Artic-Circle*, and the other the *Antartic-Circle*, and are writ thus; *Circulus sub Artico Polo*, and *Circulus sub Antartico Polo*.

These *Tropics* and *Polar Circles*, divide the Globe of the Earth into five Parts, called *Zones*; of which three were accounted by the Antients to be so intemperate as to be uninhabitable; calling them *Torrid*, *Frigid*, and *Temperate*; that is, one *Torrid* or *Burning Zone*, two *Temperate*, and two *Frigid* or *Frozen Zones*.

11. The *Torrid Zone*, is all that Space of Earth and Sea, which lieth between the *Tropics of Cancer* and *Capricorn*.

12. The two *Temperate Zones*, are contained between each *Tropic*, and a *Polar Circle*.

13. The two *Frigid Zones*, are contained within each *Polar Circle*; that is, one within the *Artic Circle*, and the other compassed by the *Antartic*.

Thus much of the Imaginary Lines, and Parts of the Earth: The Real Parts, are Earth and Water, in general divided into Four Parts or Quarters; called *Europe*, *Asia*, *Africa*, and *America*; each of these, and consequently the whole Globe, is divided into Continents, Islands, and Seas.

14. A *Continent*, is a great Quantity of Land, not divided by the Sea, wherein are many Kingdoms, and Countries conjoined;

conjoined; as *Europe, Asia, and Africa* is one Continent, and *America* is another.

15. An *Island*, is a Part of the Earth that is environ'd or compassed round by the Sea; as *Great Britain*, and also *Ireland, &c.* are Islands.

In *Continents*, and *Islands*, are these Parts observable, viz. *Peninsula, Isthmus, and Promontory.*

16. *Peninsula*, is such a Part of Land as is almost environed round with Water, and is joined to the Land by an *Isthmus*, as the *Morea* in the *Levant*.

17. An *Isthmus*, is a narrow Neck of Land between two Seas, which joineth the Peninsula to the Continent; as *Corinth* in *Greece*.

18. A *Promontory*, is a high Hill, Mountain, or Cape of Land that shooteth it self into the Sea; as *Cape de Verde*, and the *Cape of Good Hope* in *Africa*.

19. A *Place*, in respect to the Heavens, is either East, West, North, or South.

These Places are said to be East, which lie in the Eastern Hemisphere (terminated by the First Meridian) or where the Sun riseth.

And those are West, which lie Westerly of the said Meridian, or towards the Setting of the Sun.

Those Places are properly North, which lie betwixt the Æquator and the Artic Pole.

And those Places are South, which lie betwixt the Æquator and the Antartic Pole.

The Antients have divided the Inhabitants of the Earth, into *Periæci, Antioæci, and Antipodes.*

20. The *Periæci*, are such as live under the same Parallel, but in opposite Poinis of it; that is, they are in the same Latitude, but their Difference of Longitude is 180 Degrees.

21. The *Antioæci*, are such have the same Meridian, and equally distant from the Æquator, but the one North, and the other South: that is, two Places in one Longitude, and each equal in contrary Latitudes.

22. The *Antipodes*, are such as inhabit two Places of the Earth, which are diametrically opposite; that is, two Places, whose Difference of Latitude and Difference of Longitude is each 180 Degrees, and such Walk Feet to Feet.

The

The *Earth*, being encompassed with Water, whose Washings en furrounding the dry Land, cut out and shape many winding Bays, Creeks, and meandring Inlets, giving Terminations to the Four Regions of the Earth, and extending it self round them all, is but one continued Ocean. - Wherefore,

The *Water*, is either Ocean, Seas, Straits, Creeks, Lakes, Rivers, Bays, &c.

23. The *Ocean*, is a general Collection, or Rendezvous of all Waters.

24. The *Sea*, is a Part of the Ocean, to which we come through some Strait; as the *Mediterranean*, and *Baltick Sea*.

25. A *Strait*, is a narrow Part of the Ocean, lying betwixt two Shores, and opening a way into some Sea; as the Straits of *Gibraltar*, that leads into the *Mediterranean Sea*; and the *Sound*, which leadeth into the *Baltick-Sea*.

26. A *Creek*, is a small narrow Part of the Sea, or River, that goeth up but a little Way into the Land.

27. A *Bay*, is a great Inlet of the Land, as the Bay of *Biscay*, and the Bay of *Mexico*; otherwise a Bay is a Station, or Road for Ships to anchor in.

28. A *River*, is a small Branch of the Sea, flowing into the Land, courting the Banks, whilst they their Arms display, to embrace her silver Waves.

29. A *Lake*, is that which continually retains and keeps Water in it; as the Lake *Zair* in *Africa*, and Lake *Nicurgua* in *America*.

30. A *Gulph*, is an Inlet of the Land, deeper than a Bay, as the Gulph of *Venice*; the Gulph of *Florida*; in which are swift Currents.

Of the Names of the Ocean.

31. The *Ocean*, according to the Four Quarters, had four Names; as the *Eastern* or *Oriental Ocean*; the *Western* or *Occidental Ocean*, the *Northern* or *Septentrional*; and the *Southern* or *Meridional Ocean*. But besides these, it hath other particular Names according to the Continent it boundeth, and the Nature of the Sea. As it lies extended towards the East, 'tis called the *Chinean Sea*, from the adjacent Country of *Chinea*: Towards the South, 'tis called *Oceanus Indicus*, or the *Indian Sea*: where it washeth the Coast of *Persia*, 'tis called *Mare Persicum*: In like manner, *Mare Arabicum* from *Arabia*; and so towards the West, 'tis the *Ethiopian Sea*,
Then

Then the *Atlantic Ocean*, from *Atlas* a Mountain in *Africa*: But near to *America*, 'tis called by the *Spaniards*, *Mar-del-Nort*; and on the other Side of *America*, 'tis *Mar-del-Zur*, or *Mare Pacificum*.

Where it toucheth upon *Spain*, 'tis *Oceanus Hispanicus*; by the *English*, the Bay of *Biscay*: Between *England* and *France*, 'tis called the *English Channel*: Between *England* and *Ireland*, the *Irish Sea*, or *St. George's Channel*: Between *England* and *Holland*, by some the *German*, but rather the *British Ocean*: Northward of *Scotland*, 'tis called *Mare Caledonium*: More Northerly, 'tis the *Hyperborean*, or *Frozen Sea*: More Easterly, 'tis the *Tartarian Sea*, or *Scythian Ocean*, &c. Thus for the Names of the Ocean. Next,

Of the Names of the Seas.

32. The *Baltic Sea*, by the *Dutch* the *Oost Zee*, lying between *Denmark*, *Sweden*, and *Germany*, whole Entrance is called the *Sound*: The *Mare Mediterraneum*, by the *English* the *Straits*; by the *Spaniards*, *Mar-del Levant*; the Entrance whereof is called the *Straits of Gibraltar*: Then *Pontus Euxinus*, or the *Black Sea*; to which joins *Meotis Palus*, now *Mar-del Zabetché*: Then the *Caspian*, or *Hercanean Sea*: Then the *Arabian Gulf*, *Mare Rubrum*, or the *Red Sea*: And the *Persian Gulf* or *Gulf de Elcatiff*, &c.

Of the Division of the Earthly Globe.

33. The *Globe* of the *Earth* (as was said before in *Def. 13.*) is divided into four Parts, viz. *Europe*, *Asia*, *Africa*, *America*.

34. *Europe* is bounded towards the North by the Northern Ocean, or *Frozen Sea*; on the South by the *Mediterranean Sea*, lying betwixt it and *Africa*; on the East with the River *Tanais*; and on the West by the Western, or *Atlantic Ocean*; whose Chief Provinces are,

<i>Poland,</i>	<i>Muscovia,</i>	<i>Sweden,</i>	<i>Norway,</i>
<i>Denmark,</i>	<i>Germany,</i>	<i>France,</i>	<i>Spain,</i>
<i>Portugal,</i>	<i>Italy,</i>	<i>Hungary,</i>	<i>Sclavonia,</i>
<i>Greece,</i>	<i>Dalmatia</i>	<i>Romania,</i>	<i>Part of Tartaria.</i>

The principal Islands are,

<i>Great Britain,</i>	<i>Ireland,</i>	<i>Sardinia,</i>	<i>Sicily,</i>
<i>Corfica,</i>	<i>Candia,</i>	<i>Negropont</i>	<i>Cyprus.</i>

35. *Asia*, is bounded on the North with the Northern, and *Tartarian Ocean*; on the South with the *Arabian Gulph*, or *Red Sea*; on the East with the *Indean Ocean*; and on the West with the River *Tanais*. The

The chief Regions are,

<i>Turky in Asia,</i>	<i>Arabia,</i>	<i>Tartaria,</i>	<i>Persia,</i>
<i>Anatolia,</i>	<i>Mesopotamia,</i>	<i>Affyria,</i>	<i>Chaldea,</i>
<i>Syria,</i>	<i>Armenia,</i>	<i>Palestina,</i>	<i>Georgia,</i>
<i>Media,</i>	<i>Parthia,</i>	<i>China,</i>	<i>India.</i>

The principal Islands are,

<i>Japan,</i>	<i>Sumatra, Borneo, &c. in the Oriental Ocean.</i>
<i>Cyprus,</i>	<i>Rhodes, in the Mediterranean.</i>
<i>Metellino,</i>	<i>Scio, Samos, &c. in the Archipelagus.</i>

36. *Africa* is bounded on the North with the *Mediterranean*, on the East with the *Red-sea*, on the South with the *Æthiopic* or Southern Ocean, and on the West with the *Atlantic Ocean*.

The Principal Provinces are,

<i>Ægypt,</i>	<i>Barbary,</i>	<i>Billedulgerid.</i>
<i>Defarts of Sarra,</i>	<i>Negroland,</i>	<i>Æthiopia, or Abyssina.</i>
<i>Nubia,</i>	<i>Monomotapa.</i>	

Its Islands are,

<i>The Canary Islands,</i>	<i>Cape de Verde Islands,</i>
<i>The Isles of Azores,</i>	<i>Madera Islands,</i>
<i>St. Thomas,</i>	<i>Madagascar, or St. Lawrence.</i>
<i>Malta, in the Mediterranean.</i>	

37. *America*, is bounded on the North with the Northern Ocean, on the East with the *Atlantic Ocean*, on the South with the *Magellanic-sea*, and on the West with the *South-Sea*, or *Mar del Zur*: It's divided into two Parts, viz. *Mexicana*, and *Peruana*.

Mexicana, or North *America* hath these Provinces;

<i>New-Spain,</i>	<i>Terra Florida,</i>	<i>Carolina,</i>	<i>Virginia, and</i>
<i>Maryland,</i>	<i>Pensylvania,</i>	<i>New-Jersey,</i>	<i>New-York,</i>
<i>New-England,</i>	<i>New-France,</i>	<i>Greenland,</i>	whether Continent
			or Island is not yet known.

The chief Islands of *Mexicana* are,

Island, or Ice-land, California, New-found-land, Bermudas,

Paruana or South *America*, hath these Provinces;

Terra Magellanica, Brazilla, Chili, The Amazons, Guianea,

Peru, Panama, Carthagenæ, Peraguay, or Rio-de-la-Plata.

The Principal Islands of *Paruana* are,

Hispaniola, Cuba, Jamaica, Port-Rico, Barbadoes, and the rest of the Caribbee-Islands, &c.

Moluque Islands, Java-Major, Java the less, and many other Islands in the East-Indies.

Having

Having described the Lines and Circles, and the Parts belonging to the Terrestrial Globe, the Uses of all take in the following Problems.

Problem 1. *To find the Latitude of any Place upon the Globe.*

The Rule. Bring the proposed Place just under the Brass Meridian, and note what Degree (on the said Meridian) stands against it, which is the Latitude thereof. Or thus,

With a pair of Compasses, take the nearest Distance from the proposed Place (on the Globe) to any Parallel of Latitude, and lay it on the graduated, or first Meridian from the said Parallel, the same way the proposed Place lieth from it, the other Foot sheweth the Latitude required.

Example. Let it be required to find the Latitude of the Lizard in England?

Turn the Body of the Globe 'till the *Lizard* be just under the Brass Meridian, and you'll find 50 Degrees right against it; which is the Latitude of the *Lizard*. Or thus,

Take the nearest Distance (on the Globe) from the *Lizard* to any Parallel of Latitude; apply the same to the graduated Meridian, and it sheweth the Latitude 50 Degrees as before.

Note. All those Circles on the Globe, which are parallel to the *Æquator*, are called *Parallels of Latitude*.

Problem 2. *To find the Longitude of any Place on the Globe.*

The Rule 1. Turn (as before) the Globe 'till the proposed Place lies just under the Brass Meridian, and there keep it steady.

2. Then observe what Degree of the *Æquator* lieth under the Brass Meridian, and that's the Longitude required.

Example. I demand the Longitude of the *Lizard* in England?

Bring the *Lizard* under the Brass Meridian, and then the Brass Meridian cutteth the *Æquator*, in 19d. 56m. the Longitude required.

Note; The Globes formerly made in England begun Longitude at the Meridian of the Island of *St. Michael*, one of the Isles of the *Azores*, which is West from the Meridian of *London* (according to the *Mariner's Compass Rectified*) 25d. 20m.

And accordingly the *Lizard's* Longitude is 5d. 24m. West from *London*: This Difference in the Longitude of Places, is occasioned by the different Beginnings of Longitude by several Authors, which the Student is desired to consider. Prob.

Problem 3. *To find the Distance of any two Places on the Globe.*

The Rule. 1. Lay the Beginning of the Degrees on the Quadrant of Altitude, upon one of the proposed Places, and count how many Degrees on it, are contained between both Places, which is the Distance required.

2. Those Degrees being multiplied by 60, the Product is the Distance in Minutes. Or thus,

Take the Distance between the two Places with a pair of Compasses; then measure that Distance on the *Æquator*, counting the Degrees intercepted between both Feet, and it will shew the Distance required.

Note; The Distance found by this *Problem*, is the shortest Distance; or their Distance in the Arch of a Great Circle, which is less than their Distance in the Rumb, leading from one to the other; except both Places lie under one Meridian, or in the *Æquator*.

Example.

I demand the Distance between the Lizard and the Island Barbadoes?

If you lay the Edge of the Quadrant of Altitude on both Places, and the Beginning of the Degrees of it on one of the Places, you will find on the Quadrant of Altitude 56 Degrees intercepted between them, which is the Distance; and being multiplied by 60, is 3360 Miles or Minutes.

Problem 4. *To find the Angle of Position of Places; that is, The Angle, the Arch of a Great Circle passing over two given Places, makes with the Meridian of either of them.*

The Rule. 1. Rectify the Body of the Globe to the Latitude of one of the given Places.

2. Bring the same Place under the Brass Meridian, and there stay the Body of the Globe.

3. Screw the Quadrant of Altitude fast on the Brass Meridian, right over the said Place.

4. Then lay the graduated Edge of the Quadrant of Altitude to the other Place, and the said Edge will cut the Horizon in the Degree of Position required.

Example. Let it be required to know the Angle of Position of Barbadoes from the Lizard?

1. Bring the *Lizard* to the Brass Meridian, and there resting the Body of the Globe, you will find the Latitude of the *Lizard* to be 50 Degrees.

2. Move

2. Move the Brass Meridian (keeping the Body of the Globe fixed as before) higher or lower, until 50 Degrees on it do cut the Horizon (on the North side thereof,) then is the Globe rectified to the Latitude of the *Lizard*: The like you must do in Rectifying the Globe for any other Place, or Latitude.

3. Screw the Quadrant of Altitude to 50 Degrees on the Brass-meridian, which is just over the *Lizard*, (if the Globe be not turned from its Position as in the first step hereof) and turn the graduated Edge of it to *Barbadoes*, the said Edge will point on the Horizon to 71d. 30m. South Westerly; which is the Angle of Position of *Barbadoes* from the *Lizard*; that is, the Angle, the Arch of a great Circle passing through, or over the two Places, makes with the Meridian of the *Lizard*, which is not the Rumb, leading from the first to the second: For, if you rectify the Globe to the Latitude of *Barbadoes*, and so proceed as before directed, you will find the Angle of Position to be 37d. 30m. North-Easterly, the Position of the *Lizard* from *Barbadoes*, which is 34 Degrees less than the Position of *Barbadoes* from the *Lizard*; whereby it appears neither of these are the true Rumb, or Point of the Compass leading from one Place to the other. For you are to *Note*;

1. That the Rumb-lines, or Points of the Compass, make equal Angles with all Meridians on the Globe.

2. That an equal Segment, or part of the said Rumb, changeth, or altereth the Latitude in all Places equally.

3. That the Rumb-Lines, tho' continued never so far, do not pass through the Poles, but wind about them 'till they lose themselves.

4. These Rumb-Lines are represented upon the Globe by those Spiral Lines, which you see are 32 in Number, meeting in a Center, where there is a *Flower-de-Luce* pointing to the North; from thence they run winding about the Globe, and continue inclining towards the Pole, where they seem confused.

Problem 5. *Two Places being given; to find their Rumb, Bearing, or Course in Sailing from one to another.*

The Rule. 1. Having found the two Places on the Globe, see what Rumb-Line passes through both of them, and that is the Rumb, or Course from one to another.

2. If no Rumb-Line pass through both Places, then observe which runneth Parallel to both Places, and that is the Rumb, or Course from one to the other.

Examp,

Example 1. *I demand the Course from the Lizard to Cape Cod in New England?*

On the Globe you will find these Places to lie on the W. by S. and E. by N. Rumb Line, and therefore the Course from the *Lizard* to *Cape Cod*, is W. by S. and consequently from *Cape Cod* to the *Lizard* E. by N.

Example 2. *I demand the Course from the Lizard, to the Island Barbadoes?*

Here no Rumb-Line on the Globe passeth over them; wherefore look for a Rumb to which the Place lies most parallel, and you'll find it S. W. $\frac{1}{2}$ W. the Course from the *Lizard* to I. *Barbadoes*; and N. E. $\frac{1}{2}$ E. from I. *Barbadoes* to the *Lizard*.

Problem 6. *Course and Distance sailed being given; to find the Difference of Latitude, and Difference of Longitude.*

The Rule. 1. Make a small Mark on that Rumb-Line (which is the given Course) in the Latitude of the Place you sail from, and bring that Mark to the Brass Meridian, which cuts the Equator in its Longitude.

2. Take the Distance sailed from the Equator, and lay it on the said Rumb, from the 'foresaid Mark; at the Termination thereof make another Mark.

3. Then bring this Second Mark to the Brass Meridian, which is the Latitude of that Place; and then the Meridian cuts the Equator in the Longitude of it.

4. Having the Latitude and Longitude of those two Places mark'd in the Rumb-Line, by Subtraction you may find their Difference of Latitude and Difference of Longitude, and 'tis done.

Example. *Suppose a Ship sails S. W. by W. 260 Leagues, or 10 Degrees from the Lizard: I demand her Difference of Latitude; and Difference of Longitude; or what Latitude and Longitude she is in?*

1. Make a Mark on the S. W. by W. Rumb, just under 50 Degrees, (the *Lizard's* Latitude) and then the Meridian cuts the Equator in 357 Degrees, the Longitude of that Mark.

2. Take 10 Degrees from the Equator, and lay it on the S. W. by W. Rumb, from the First Mark to a Second Mark.

3. Bring this Second Mark to the Brass Meridian, and the Latitude of it, is 44d. 50m. the Latitude the Ship is in, and in the Equator the Longitude of it, is 344d. 15m. and by Subtraction, the Difference of Latitude is, 5d. 20m. and Difference of Longitude is, 12d. 45m. But here you must note;

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That

That, the Distance sailed intirely taken, and laid on the Rumb, is the Distance of the Arch in a Great Circle, and not really in the Rumb; for the Distance in the Great Circle is always less than the Distance in the Rumb: Wherefore, the better way will be, to take 1, 2, 3, (or some small Number of) Degrees of the Equator; and run that Distance (in the Compasses) over upon the Rumb Line, from the First Mark to the Second; and in so doing, the Distance is more truly laid, than by taking it at once.

Problem 7. *Both Latitudes, and Course given; to find the Distance, and Difference of Longitude.*

The Rule. 1. Turn the Body of the Globe 'till the given Rumb doth cut the Brass Meridian in the Latitude you depart from, and there make a Mark on the Rumb, and at the same Time, see what Degree of the Equator is cut by the Meridian; for that is the Longitude of this Mark.

2. Turn the Body of the Globe 'till the same Rumb cuts the Meridian in the Latitude of the Second Place, and there make another Mark on the Rumb; then see what Degree of the Equator is cut by the Meridian, which is the Longitude of the Second Mark; and the less Longitude subtracted from the greater, gives the Difference of Longitude required.

3. The Distance between the two Marks on the Rumb-Line, being measured (according to the Note in the last *Problem*) on the Equator, gives the Distance of the two Places.

Example. *If a Ship sails S. W. by W. from the Lizard, 'till by Observation she is in Latitude 44d. 50m. North; I demand her Distance sailed, and what Longitude she is in?*

1. Bring the S. W. by W. Rumb to cut the Meridian in 50 Degrees, the *Lizard's* Latitude, and make a Mark on that Rumb there, then the Meridian cuts the Equator in 357 Degrees, the Longitude of that Mark.

2. Turning the Globe 'till the S. W. by W. Rumb cuts the Meridian in 44d. 50m. the Latitude of the Second Place, and making there a Mark on the Rumb; then the Meridian cuts the Equator in 344d. 15m. the Longitude of the Second Mark: And therefore the *Difference of Longitude*, is 12d. 45m. West; which being subtracted from the Longitude of the *Lizard*, 20d. 00m. the Remainder is 07d. 15m. the Longitude the Ship is in.

3. Take 2 Degrees from the Equator, and run over that Distance in the Compasses upon the Rumb, from the First Mark

Mark 1^o the Second; and 'tis five $\frac{1}{2}$ Times, which is 10d. or 200 Leagues, the Distance sailed on that Rumb.

Problem 8. *Having the Latitude, and Longitude the Ship is in given; to find the Place where the Ship is in on the Globe*

The Rule. 1. Bring the Longitude to the Brass Meridian, and there stay the Body of the Globe.

2. Where the given Latitude cuts the Globe, make a Mark on the Body of the Globe, which mark is the Place of the Ship at that Time.

Example. If a Ship sails from the Lizard, and after some Time is in Latitude 44d. 50m. and Longitude 9d. 45m. I demand the Place of the Ship, on the Globe?

1. Bring 9d. 45m. on the Equator to the Brass Meridian, and there stay the Globe.

2. Just under 44d. 50m. on the Brass Meridian, make a Mark on the Body of the Globe, and that is the Place of the Ship at that Time.

Section III. *The Description of the Cœlestial Globe.*

THE *Cœlestial Globe* represents that glorious Canopy, so richly embroider'd and beset with those Sparkling Diamonds, that upon the Dusky Cheeks of the Night hang as rich Jewels in an *Ethiopean's* Ear; having upon it's Convexity artificially placed all the Stars, correspondent to their Natural Situation in the Concavity of the Orb, which we call the *Starry Heavens*.

2. The Appurtenances belonging to this, are the same with those belonging to the *Terrestrial Globe*; and being before described in *Section 1.* of this *Chapter*, I refer you to it.

3. On the Body of the Globe, besides the Constellations, there are drawn divers Circles; as the *Equinoctial*, *Ecliptic*, *Colures*, *Meridians*, and *Circles of Longitude*: All these are called Great Circles. The Lesser Circles are the *Tropics*, *Polar Circles*, and *Parallels of Declination*.

4. The *Equinoctial* in this, is the same with the *Equator* in the *Terrestrial Globe*, and in the same Manner divided; and number'd from the Left-hand towards the Right, with 10, 20, 30, &c. to 360 Degrees.

The *Poles* of the *Equinoctial* are also called the *Poles* of the *World*, and are represented by the two Wires on which the Body of the Globe turneth.

5. The *Ecliptic*, is a great Circle which crosseth the Equinoctial in two opposite Points, the Beginning of *Aries*, and *Libra*; 'tis divided into twelve (equal Parts called) Signs, each containing 30 Degrees, and figured from the Left-hand towards the Right, 10, 20, 30; then 10, 20, 30, &c. having the Figure, Character, and Name of each Sign, as followeth;

<i>Aries</i> γ	} Northern Signs	<i>Libra</i> ♎	} Southern Signs.
<i>Taurus</i> ♉		<i>Scorpio</i> ♏	
<i>Gemini</i> ♊		<i>Sagittarius</i> ♐	
<i>Cancer</i> ♋		<i>Capricornus</i> ♑	
<i>Leo</i> ♌		<i>Aquarius</i> ♒	
<i>Virgo</i> ♍		<i>Pisces</i> ♓	

This Circle with its Figures and Characters, are on both Globes; but the Cœlestial hath the Images and Names of the Signs, which the Terrestrial hath not.

Under this Circle the Sun moves in his Annual Course; but the rest of the Planets have their Deviations from it; for which Reason *Astronomers* assigned Eight Degrees on each Side the *Ecliptic*, making the whole Latitude to be 16 Degrees, which Breadth is called the *Zodiac*.

The *Zodiac*, is not drawn on the Globe, only imagined by two Circles parallel to the *Ecliptic*, at eight Degrees Distance from it on each Side thereof.

The *Poles* of the *Ecliptic*, are two opposite Points, each 23d. 30m. distant from it's correspondent Pole of the World: There the Circles of Longitude meet, and near it is writ, *Polus Eclipticæ*.

6. The *Meridians* are the same as before on the Terrestrial Globe, only with this Difference, on this they are drawn through every 30th Degree of the Equinoctial, on that through every 15th Degree of the Equator; in both, they all meet in the Poles of the World.

7. The *Colures*, are two Meridians, cutting each other at Right Angles in the Poles of the World, dividing the Equinoctial, and Ecliptic into 4 equal Parts; the one passeth thro' the Beginning of *Aries* and *Libra*, two Equinoctial Signs; therefore called the Equinoctial Colure; and on the Globe it is divided into Degrees, numbred from the Equinoctial both Ways, 10, 20, 30, &c. ending in 90 at each Pole of the World: It hath these Words near it, *Colurus Equinoctiorum*.

The other passeth through the Beginning of *Cancer* and *Capricorn*,

pricorn, two Solstitial Signs, therefore called the *Solstitial Colure*: This passeth through the Poles of the World, and Poles of the Ecliptic: 'Tis distinguished on the Globe by these Words, *Colurus Solstitiorum*.

8. The *Horizon*, is a great Circle 90^d. distant from the Zenith, and Nadir, cutting all Azimuth Circles at Right-Angles, and divideth the World into two equal Parts; the upper and visible Hemisphere, and the lower and invisible: 'Tis represented by the upper Side of the wooden Frame, on which is a double Kalendar, of Months and Days, according to the Old and New Stile, with the Winds or Points of the Compass, and a Circle of Signs with their Degrees.

The *Zenith* and *Nadir*, are two Points diametrically opposite, and are the Poles of the Horizon. The Zenith is the *Vertical Point*, or Point over Head: The Nadir is directly opposite thereto.

9. The *Azimuths*, or *Vertical Circles*, are Great Circles intersecting each other in the Zenith and Nadir, and cutting the Horizon at Right Angles: These Circles are not drawn on the Body of the Globe, but are represented by the Quadrant of Altitude, when 'tis screw'd in the Zenith.

10. *Circles of Longitude*, are Great Circles intersecting each other in the Poles of the Ecliptic, and cut it at Right Angles: These are represented by the Quadrant of Altitude when it is screw'd over the Poles of the Ecliptic; and on the Body of some Globes, 12 of these Circles are drawn, passing through the Beginning of the Twelve Signs.

Thus much for the Great Circles.

The Description of the Less Circles.

Less or *Small Circles*, are those which divide the Globe into two Unequal Parts, and are parallel to some Great Circle, therefore called *Parallel Circles*, and are of three Kinds, viz. *Parallels of Declination*, *Parallels of Altitude*, and *Parallels of Latitude*.

11. *Parallels of Declination*, are parallel to the Equinoctial, imagined to pass through every Degree and Minute of the Meridian between the Equinoctial and each Pole of the World; and are the same with the *Parallels of Latitude* on the *Terrestrial Globe*.

The *Tropics* and *Polar Circles*, are *Parallels of Declination*, and the same as before in the Description of the *Terrestrial Globe*.

12. *Almicanters, or Parallels of Altitude*, are parallel to the Horizon, imagin'd to pass thro' every Degree and Minute of the Meridian of a Place, between the Horizon and the Zenith of that Place: These are described by the Divisions on the Quadrant of Altitude in its Motion about the Body of the Globe, when it is screw'd in the Zenith of any Place.

13. *Parallels of Latitude*, are small Circles parallel to the Ecliptic, imagined to pass through every Degree and Minute of the Colures, between the Ecliptic and the Poles thereof: These are represented by the Divisions of the Quadrant of Altitude in it's Motion round the Body of the Globe, when it is screw'd over the Poles of the Ecliptic.

Having described the imaginary Circles of the Cœlestial Globe, we proceed now to the Description of the Stars, those glorious Diamonds, sparkling in the immense Expansion of the Firmament, encircling the Terrestrial Orb at unmeasurable Distance, which for Multitude seem innumerable, yet the greatest and more visible may be number'd, and nam'd: And for this Purpose *Astronomers* (for Order, and Method Sake) have reduced many Stars into one Image, or Constellation, the better to know where to seek them; and being found, how to express them.

14. The Number of Constellations now drawn on the Body of the Cœlestial Globe, are 66, and are as followeth.

The Northern Constellations are 23, viz.

	Stars		Stars
1. <i>Urfa minor</i> —————	9	12. <i>Auriga</i> —————	24
2. <i>Urfa Major</i> —————	33	13. <i>Serpentarius</i> —————	23
3. <i>Draco</i> —————	36	14. <i>Serpens</i> —————	14
4. <i>Cepheus</i> —————	11	15. <i>Sagitta</i> —————	5
5. <i>Bootes</i> —————	22	16. <i>Aquila</i> —————	9
6. <i>Corona Borealis</i> ———	8	17. <i>Antinous</i> —————	7
7. <i>Hercules</i> —————	30	18. <i>Delphinus</i> —————	10
8. <i>Lyra</i> —————	10	19. <i>Equulens</i> —————	5
9. <i>Olon, or Cygnus</i> ———	27	20. <i>Fegasus</i> —————	23
10. <i>Cassiopeia</i> —————	23	21. <i>Andromeda</i> —————	23
11. <i>Perseus, and Caput</i> {	27	22. <i>Triangulum</i> —————	3
<i>Medusæ</i> ————— }		23. <i>Coma Berenices</i> ———	11

In all 383
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The Zodiacal Constellations are 12, viz.

	Stars		Star
1. <i>Aries</i> —————	16	7. <i>Libra</i> —————	10
2. <i>Taurus</i> —————	32	8. <i>Scorpio</i> —————	26
3. <i>Gemini</i> —————	24	9. <i>Sagittarius</i> —————	29
4. <i>Canter</i> —————	16	10. <i>Capricornus</i> —————	21
5. <i>Leo</i> —————	33	11. <i>Aquarius</i> —————	34
6. <i>Virgo</i> —————	39	12. <i>Pisces</i> —————	34

In all 314

The Southern Constellations are 30, viz.

	Stars		Stars
1. <i>Cetus</i> —————	26	17. <i>Columbus</i> —————	10
2. <i>Orion</i> —————	39	18. <i>Piscis Austrinus</i> ———	11
3. <i>Flumen Eridanus</i> ———	43	19. <i>Grus</i> —————	13
4. <i>Lepus</i> —————	13	20. <i>Phœnix</i> —————	12
5. <i>Canis major</i> —————	13	21. <i>Indus</i> —————	12
6. <i>Canis minor, or Canicula</i>	2	22. <i>Pavo</i> —————	16
7. <i>Argo Navis</i> —————	42	23. <i>Avis Indica, Touchan</i> --	7
8. <i>Robur Carolinum</i> ———	11	24. <i>Apus musca</i> —————	3
9. <i>Hydra</i> —————	27	25. <i>Chamæleon</i> ———	10
10. <i>Crater</i> —————	8	26. <i>Triangulum Australe</i> —	5
11. <i>Corvus</i> —————	7	27. <i>Piscis Volans</i> —————	7
12. <i>Centaurus</i> —————	30	28. <i>Derado</i> —————	7
13. <i>Lupus</i> —————	22	29. <i>Apous, Anser Americanus</i>	10
14. <i>Crosero, or the Crofiers</i>	5	30. <i>Hydra, Serpens Austrina</i>	10
15. <i>Åra, or the Altar</i> ———	8		
16. <i>Carona Austrina</i> ———	10		

In all 439

The Sixty Sixth constellation (lying near *Urfa major*) was added by Sir *Charles Scarborough*, and called *Cor Caroli*; being one Star in a crowned Heart, and compleats a Catalogue of 1137 fixed Stars as above: But this Number is now largely encreas'd by the Observation of our modern Astronomers, as may be seen in the *Flamsteedian* Catalogue, which contains about 3500, forming several new Asterisms, and are distinguished, into *Six Degrees of Magnitude*, or Bigness. The biggest, and brightest are called *Stars of the First Magnitude*; those next inferior in Bigness, and Brightness, are *Stars of the Second Magnitude*, &c. unto *Stars of the Sixth Magnitude*. These several Magnitudes are expressed on the Globe in several Shapes, as may be seen in a little Table placed on the Globes and intituled *Stellarum Magnitudines*.

Section IV. *The Use of the Cælestial Globe.*

BEfore working any *Problem* on this *Globe*, I hold it necessary to explain several *Words of Art* used in *Astronomy*, and *Geography*, and are in these following *Definitions*.

1. *Altitude*, is an Arch of an *Azimuth Circle*, contained between the *Horizon* and any *Parallel of Altitude*. 'Tis counted on the *Brass Quadrant of Altitude*, which represents any *Azimuth Circle* on the *Globe*.

2. *Ascension*, is the *Rising* of the *Sun* or *Star*, or any *Part* of the *Equinoctial* above the *Horizon*: And *Descension* is the *Setting* thereof.

3. *Right Ascension*, is an Arch of the *Equinoctial*, intercepted between the *Beginning of Aries*, and any *Meridian*, and counted according to the *Order*, and *Succession* of the *Signs*: Or, 'tis that *Degree* and *Minute* of the *Equinoctial*, (counted as before) which cometh to the *Meridian* with the *Sun*, *Star*, or with any *Point* of the *Heavens*.

4. *Oblique Ascension*, is that *Degree* and *Minute* of the *Equinoctial*, (counted as before) which riseth with the *Center* of the *Sun*, or *Star*, or with any *Point* of the *Heavens*: And *Oblique Descension* is the *Setting* thereof.

5. *Ascensional Difference*, is the *Difference* between the *Right* and *Oblique Ascension*, or *Descension*: Or, it is the *Space of Time* the *Sun* *Riseth*, or *Setteth* before, or after *Six* of the *Clock*.

6. *Amplitude*, is an Arch of the *Horizon* comprehended between the true *East* and *West* *Points* of it, and the *Center* of the *Sun*, or *Star*, at their *Rising*, or *Setting*.

7. *Azimuth*, is an Arch of the *Horizon* contained between the *Meridian* of the *Place*, and any other *Azimuth Circle*; or contained between the *Prime Vertical*, and any other *Azimuth Circle*.

8. *Declination*, is an Arch of a *Meridian*, comprehended between the *Equinoctial*, and the *Center* of the *Sun* or *Star*, or any *Point* of the *Heavens*: It is *North Declination* on the *North Side* of the *Equinoctial*, but *South Declination* when on the *South Side* thereof. And is counted on the *Brass Meridian* on the *Globe*, and on the *Equinoctial Colure*.

9. *Hour of the Day*, or *Night*, is an Arch of the *Equinoctial*, contained between the *Meridian* of the *Place*, and another *Meridian* passing through the *Center* of the *Sun* at any *Time*. This is counted on the *Brass Hour Circle*, which is divided

divided into the 24 Hours of the Day, and Night; and hath a little Brass Index pointing to them as the Globe is turned about: Or it is counted on the Equinoctial, Reckoning 15d. to an Hour.

10. *Latitude of a Star*, is an Arch of a Circle of Longitude, contained between the Ecliptic and the Star's Center: This is counted on the Brass Quadrant of Altitude, when screw'd over the Pole of the Ecliptic, for then it represents a Circle of Longitude.

11. *Latitude of a Place*, or *Latitude upon the Earth*, is an Arch of the Meridian of that Place, contained between the Equator and that Place: Equal to which, is the Height of the Pole (of the World) above the Horizon. This is counted on the Brass Meridian of the Globe: Or it may be counted on the graduated Meridian on the Body of the Globe.

So that *Latitude in the Heavens*, and *Latitude on the Earth*, are different Things; one being an Arch of a Circle of Longitude, and applicable to the Planets (except the Sun, who hath no Latitude) and Stars: The other an Arch of a Meridian, and applicable to Places on the *Earth*.

12. *Longitude in the Heavens*, is an Arch of the Ecliptic, comprehended between the Beginning of *Aries*, and that Circle of Longitude which passeth through the Center of the Sun, Star, or any Point of the Heavens, and counted according to the Succession of the Signs.

13. *The Place of the Sun, or a Star, with respect to the Ecliptic*, is the Sign, (and Degree, and Minute of that Sign) the Sun, or Star is in.

14. *Longitude of the Sun, or of a Star, from the nearest Equinoctial Point*, is how many Degrees and Minutes, the Sun, or Star is from the Beginning of *Aries*, or *Libra*; either before, or after them; which can never be more than 180 Degrees.

15. *Longitude on the Earth*, is an Arch of the Equator, comprehended between the Meridian of any Place, and that Meridian where Longitude takes its Beginning.

So that *Longitude in the Heavens*, and *Longitude on the Earth* are vastly different; one being an Arch of the Ecliptic, the other an Arch of the Equator.

16. *Meridian of a Place*, is that Meridian which passeth over the Zenith of that Place; to which when the Sun cometh, 'tis either Noon or Midnight: At the First, he is at his highest Altitude above the Horizon; and at the Last, he is at the lowest Depression for that Day.

In like manner, any Star coming to the Meridian of any Place, is then at the highest Altitude, or lowest Depreffion.

These Things being well confider'd, the following *Problems* will be the better understood.

Problem 9. *The Day of the Month given: to find the Sun's Place in the Ecliptic.*

The Rule. 1. Seek the Day of the Month, (in either Account according to the *Julian*, or *Gregorian* as you find them placed in the *Kalendar*) on the upper Side of the Horizon.

2. Right against it, in the innermost Circle, is the Sign, Degree, and Minute, the Sun will be in that Day at Noon.

Example. *The 8th Day of January in the Julian, or the 19th in the Gregorian Account, I demand the Sun's Place in the Ecliptic?*

Right against the 8th of *January*, in the *Julian Kalendar*, in the Circle next within it, is 19 Degrees of *Capricorn*, in which Sign and Degree the Sun will be on the 8th of *January*.

In like manner his Place for *February* the 15th, is 7d. 30m. in *Pisces*.

Problem 10. *How to rectify the Globe for any Latitude, and to make it fit for Use, at any given Time.*

The Rule. 1. The Globe being placed in the Frame, by putting the Brass Meridian into the two Notches, that are in the North and South Parts of the Horizon, so that the graduated Side thereof be towards the East, and it rests in the Notch, that is in the Bottom of the Frame: Move the said Meridian higher or lower, 'till the given Latitude in it doth just touch the upper Part of the Horizon, on the North Side thereof, if North Latitude, but the South Side, when South Latitude.

2. Place the Brass Hour Circle about the Pole, so that the Hours of 12 and 12 lie directly over the graduated Side of the Brass Meridian; and put the little Index on the Axis, so that it may move about as you turn the Globe; then doth the upper 12 on the Hour Circle represent 12 at Noon, and the lower, 12 at Midnight; and all the other Figures, correspondent Hours of the Day and Night.

3. By *Problem 9*. Find the Sun's Place according to the given Time; then seek the Sun's Place in the Ecliptic, on the Body of the Globe, and bring that Degree to the Meridian; there stay the Globe, and then turn the little Index 'till it points just at the upper 12 in the Hour Circle.

Thus is the Globe rectify'd to the given Latitude, and the Hour Circle and Index to the given Time.

Example. At London the 14th of February, I would have the Globe rectify'd fit for Use?

1. Move the Brass Meridian 'till 51d. 32m. on it, toucheth the North Part of the Horizon.

2. By *Problem 9.* The Sun's Place is 6d. 30m. in Pisces; which being found in the Ecliptic on the Globe, bring it to the Brass Meridian, and there staying the Globe, turn the little Index to the upper 12 in the Hour Circle; and there set it so, that it may move with the Globe, and 'tis done.

Problem 11. The Day of the Month given; to find the Sun's Declination.

The Rule. 1. By *Problem 9.* Find the Sun's Place in the Ecliptic.

2. Bring the Sun's Place (in the Ecliptic on the Globe) to the Brass Meridian, on which, and right over the Sun's Place is his Declination required.

Example. The 14th of February; I desire to know the Sun's Declination?

1. The Sun's Place in the Ecliptic, for the 14th of February (found by *Problem 9.*) is 6d. 30m. in ♈.

2. Bring 6d. 30m. in ♈ (in the Ecliptic on the Globe) to the Brass Meridian, and then right over it (on the Brass Meridian) is 9d. 10m. which is the Sun's Declination, South Declining. Or thus,

1. With a Pair of Compasses take the nearest Distance from the Sun's Place in the Ecliptic 6d. 30m. in ♈, to the Equinoctial on the Globe.

2. Measure that Distance on the Equinoctial Colure, and it sheweth the Declination 9d. 10m. as before.

Problem 12. The Day of the Month given; to find the Sun's Right Ascension.

The Rule. 1. As before, find the Sun's Place in the Ecliptic, by *Problem 9.*

2. Bring the Sun's Place (as directed in *Problem 11.*) to the Brass Meridian; look what Degree of the Equinoctial is cut by it, and that is the Sun's Right Ascension required.

Example. The 14th of February; I demand the Sun's Right Ascension?

1. The 14th of February, his Place in the Ecliptic is 6d. 30m. in ♈, by *Problem 9.*

2. His

2. His Place of 6d. 30m. of $\times$, being brought to the Brass-Meridian, it cuts the Equinoctial in 338d. 15m. the Sun's Right Ascension.

Problem 13. *The Latitude of a Place, and the Day of the Month given; to find the Time of the Sun's Rising, Setting, and his Amplitude?*

The Rule. 1. Rectify the Globe (by *Problem 10th*, fit for Use) according to the given Latitude, and given Time.

2. Bring the Sun's Place (in the Ecliptic on the Globe) down to the Horizon on the East Side thereof, and then the little Index will point to the Sun's Rising in the Hour Circle; and the Body of the Globe stayed there, look what Degree of the Horizon (counted from the East Point thereof) standeth right against his Place (in the Ecliptic on the Globe) that is the Sun's Amplitude at his Rising.

In like manner, turn the Globe 'till you bring the Sun's Place to lie even with the West Side of the Horizon, staying the Body of the Globe there; then will the Index point to his Setting, and against his Place on the Globe standeth his Amplitude, (on the Horizon) counted from the West Point thereof.

Example. *The 14th of February at London: I demand the Time of the Sun's Rising and Setting, and his Amplitude?*

1. The Globe being Rectified to the Latitude of 51d. 32m. and the Hour Index to 6d. 30m. of $\times$, then 'tis Rectified to the given Latitude, and given Time.

2. Bring 6d. 30m. of $\times$, to the East Side of the Horizon, and staying the Globe there, the Index points to 6 Hours $\frac{3}{4}$; that is, $\frac{3}{4}$ after 6 is the Sun's Rising; and against 6d. 30m. of $\times$, is 14d. 35m. on the Horizon, (from the East towards the South) which is the Sun's Amplitude at Rising.

In like manner, turn the Globe 'till you bring 6d. 30m. of $\times$, to the West Side of the Horizon, and the Index points to $\frac{1}{2}$ after 5, which is the Sun's-Setting; and in the Horizon you have his Amplitude (the same as before) 14d. 35m. from the West (towards the South) which is the Sun's Amplitude at Setting.

Problem 14. *The Latitude of a Place, and the Day of the Month given; to find the Sun's Oblique Ascension and Descension?*

The Rule. 1. Rectify the Globe to the given Latitude, and find the Sun's Place in the Ecliptic for the given Time.

2. Bring

2. Bring the Sun's Place in the Ecliptic on the Globe, to the East Side of the Horizon, and then see what Degree of the Equinoctial is cut by the Horizon, and that is the Sun's Oblique Ascension.

3. In like manner bring the Sun's Place in the Ecliptic to the West Side of the Horizon, and it sheweth his Oblique Descension.

Example. *The 14th of February at London: I demand the Sun's Oblique Ascension and Descension?*

1. Rectify the Globe to the given Latitude 51d. 32m. according to Problem 10.

2. Bring 6d. 30m. of ♈ (the Sun's Place for the 14th of February) to the East Side of the Horizon, and then it cuts the Equinoctial in 349d. 50m. which is the Sun's Oblique Ascension.

3. Bring 6d. 30m. of ♈ to the West Side of the Horizon, it cuts the Equinoctial in 326d. 30m. which is the Sun's Oblique Descension.

Prob. 15. *The Latitude of Place, and Day of the Month given; to find the Sun's Altitude, and Azimuth at any Time of the Day.*

The Rule. 1. Rectify the Globe and Hour-Index, as before, in Problem 10.

2. Screw the Quadrant of Altitude in the Zenith; which I call rectifying the Quadrant of Altitude to the Latitude of the Place.

3. Turn the Globe 'till the Index point to the given Hour of the Day, and there stay the Globe.

4. Move the Quadrant of Altitude, 'till the graduated Edge of it lie just on the Sun's Place in the Ecliptic on the Globe, and there stay it.

5. Look what Degree on the Quadrant of Altitude is against the Sun's Place, and that is the Sun's Altitude.

6. Look what Degree of the Horizon is cut by the Graduated Edge of the Quadrant of Altitude, counted from the North, or from the South, and that is the Sun's Azimuth.

Example. *At London the 17th of June, at 6 of the Clock in the Forenoon; I demand the Sun's Altitude, and Azimuth?*

1. The Globe being Rectified (by Problem 10) turn it about 'till the Hour Index points to 6 in the Morning, and there stay the Body of the Globe.

2. Screw the Quadrant of Altitude on 51d. 32m. (on the Brass Meridian) which is the Zenith, or London's Distance from the Equinoctial.

Notes

Note; In screwing the Quadrant of Altitude on the Brass Meridian, you must put the Screw Side of the Notch, on the Back-side thereof, and put it close down; so close to it, that the thin Plate may be as near the Body of the Globe as possibly you can; yet so, as not to obstruct its moving.

Also mind that you set the sloped Edge of the Notch of the Latitude of the given Place.

3. Bring the graduated Edge of the Quadrant of Altitude, to 6d. 10m. of ☿, the Sun's Place (for *June* the 17th) in the Ecliptic, and then on the Quadrant of Altitude (against it) is 18d. 30m. his Altitude at 6 of the Clock.

4. And the Quadrant of Altitude cuts the Horizon, in 104d. 50m. from the South Eastward, which is the Sun's Azimuth at the same Time.

Problem 16. *The Latitude of a Place, the Day of the Month, and Sun's Altitude given; to find his Azimuth, and Hour of the Day?*

The Rule. 1. Rectify the Globe, Hour Index, and Quadrant of Altitude, as before.

2. Turn the Body of the Globe, and move the Quadrant of Altitude, 'till you bring the Sun's Place in the Ecliptic to lie just under his Altitude on the Quadrant; there stay them both.

3. Then will the graduated Edge of the Quadrant point out the Azimuth, in the Horizon from the North, or South; and the Index sheweth the Hour of the Day.

Example. *At Barbadoes the 14th of February, in the Forenoon, the Sun's Altitude being 30d. I demand his Azimuth, and Hour of the Day?*

1. The Globe being Rectified to the Latitude of *Barbadoes*, 13d. 25m. also the Hour Index to 6d. 30m. of ♄, the Sun's Place for the 14th of *February*, and the Quadrant of Altitude screwed in the Zenith.

2. Then move the Globe and Quadrant of Altitude, 'till you bring 30 Degrees on the latter to lie just over 6d. 30m. of ♄ in the Ecliptic, and there stay them both.

3. Then doth the Quadrant of Altitude lie right against 72d. in the Horizon, from the South towards the East, the Sun's Azimuth, which is almost E S E. $\frac{1}{2}$ E.

4. And then the Hour Index points to 8 Hours $\frac{1}{4}$, that is, 45m. after 8 of the Clock in the Morning.

Problem

Problem 17. *The Latitude of a Place, the Day of the Month, and Sun's Azimuth given; to find his Altitude, and Hour of the Day.*

The Rule. 1. Rectify the Globe, Hour Index, and Quadrant of Altitude, as before.

2. Turn the Quadrant of Altitude, to the given Azimuth, in the Horizon, and there stay it.

3. Then bring the Sun's Place in the Ecliptic (keeping the Quadrant of Altitude fixed) to the graduated Edge thereof, (which is also before set to his given Azimuth;) and stay the Globe there.

4. Then doth the Ecliptic cut the Quadrant in the required Altitude, and the Index sheweth the Hour of the Day desired.

Example. At Barbadoes the 14th of February, the Sun's Azimuth in the Afternoon, being W.S.W. $\frac{1}{2}$ W. or 73d. 07m. South Westerly; I demand his Altitude, and Hour of the Day?

Ans. Observing the aforesaid Directions, and turning the Globe, and Quadrant of Altitude towards the West, you will find the Sun's Altitude to be 30d. and the Hour of the Day 15m. after 3 in the Afternoon.

Problem 18. *The Latitude of a Place, the Sun's Altitude, and Azimuth given; to find his Place in the Ecliptic, and Hour of the Day.*

The Rule. 1. Rectify the Globe to the Latitude, and screw the Quadrant of Altitude to the Zenith.

2. Turn the graduated Edge of the Quadrant of Altitude to the given Azimuth, in the Horizon, and there stay it.

3. Turn the Body of the Globe (without stirring the Quadrant out of it's Place) 'till the Ecliptic cut the Quadrant in the given Altitude; which will then cut the Ecliptic in the Sun's Place required.

4. Then turn the Sun's Place to the Brass Meridian, and rectify the Hour Index to 12.

5. Turn back the Sun's Place to the graduated Edge of the Quadrant (it being in the same Place; that is, at the given Azimuth as before) and then the Index will shew the Hour of the Day required.

Note; In turning the Globe according to the third Step in this Rule, the given Altitude in the Quadrant will cut the
Ecliptic

Ecliptic into two several Signs, and yet the Hour of the Day sought by the Fourth Step, will be the same; so that unless the Month be given, the Sun's Place cannot be determin'd.

Example. At London, the 5th of October, the Sun's Altitude being 20d. and his Azimuth S. E. or 45d. S. Easterly: I demand his Place in the *Ecliptic*, and the Hour of the Day?

Answer. The Sun's Place is 23d. 30m. in φ , and 'tis 7m. after 9 in the Morning, the 5th of October at London: Also the Sun's Altitude and Azimuth being the same, his Place may be 6d. 30m. in κ , and the Hour the same, the 14th of February.

Note; All these Problems may be wrought, having the Sun's Declination given, instead of the Day of the Month, which may be seen in the next Problem.

Problem 19. *The Latitude of a Place, the Declination, and Altitude of the Sun given; to find his Azimuth, and Hour of the Day?*

The Rule. 1. Rectify the Globe to the given Latitude, and the Quadrant to the Zenith as before.

2. Bring the Equinoctial Colure to the Brass Meridian, and then set the Hour Index to the upper 12; which is Rectifying the Globe when the Declination is given.

3. Move both Globe, and Quadrant of Altitude, 'till the given Altitude on the latter meet with the given Declination in the Equinoctial Colure on the former, and there stay them both.

4. Then doth the Quadrant cut the Horizon in the Sun's Azimuth, and the Index sheweth the Hour of the Day required. Also, at the same Time, the Brass Meridian cuts the Equinoctial in so many Degrees (counting from the Colure, allowing 15d. to an Hour) as the required Hour of the Day is, either before, or after Noon.

Example. At London, the Sun's Declination being 15d. North, and his Altitude 19d. 30m. in the Morning: I demand his Azimuth, and Hour of the Day?

Answer. The Sun is East, and the Hour 52m. after 6 o'clock, or 77d. of the Equinoctial are intercepted between the Equinoctial Colure and Brass Meridian; which makes 5h. 8m. from Noon, at which Time the Sun is West in the Afternoon.

In like manner may any of the preceding Problems be wrought, observing these following General Directions.

1. Count the Latitude on the Brass Meridian.
2. The Declination on the Colure from the Equinoctial, either Northward or Southward, according to its Name.
3. The Altitude on the Quadrant of Altitude.
4. The

4. The Azimuth on the Horizon, from the Brass Meridian to the Quadrant of Altitude.

5. And the Hour (from Noon in Degrees) on the Equinoctial, from the Equinoctial Colure to the Brass Meridian.

Then having any Three of these Five given, the other Two may be found, which I leave for the Learner's Exercise.

Note ; All the foregoing Problems, may be wrought on either Globe ; but the following only on the *Caelestial Globe*.

Problem 20. *To find the Declination, and Right Ascension of any Fixed Star.*

The Rule. 1. Bring the given Star to the Brass Meridian, and there stay the Globe.

2. Then the Center of the Star cuts the Brass Meridian in it's Declination, counted from the Equinoctial either Northward, or Southward.

3. And the Brass Meridian cuts the Equinoctial in it's Right Ascension, counted from the Beginning of γ , according to the Succession of the Signs.

Example. *I demand the Right Ascension, and Declination of Aldebaran, or Oculus Tauri, the Bull's Eye?*

Answer. According to the Directions above, you will find it's Right Ascension 63d. 03m. and its Declination near 15d. 55m. North.

Problem 21. *To find the Latitude, and Longitude of a Star.*

The Rule. 1. Bring the Solstitial Colure to the Brass Meridian, that the Pole of the Ecliptic on the Globe may be just under 23d. 30m. on the said Meridian, and there fix the Body of the Globe.

2. Screw the Quadrant of Altitude just over the Pole of the Ecliptic.

3. Bring the Graduated Edge of the said Quadrant to the Center of the Star, and there stay it.

4. Then the Star cuts the Quadrant in it's Latitude, and the Quadrant cuts the Ecliptic in it's Longitude.

Example. *I demand the Latitude, and Longitude of Arcturus, a Star of the first Magnitude in the Constellation Bootes?*

Answer. This Star's Latitude is 30d. 57m. North, and its Longitude 20d. 24m. in α , or 200d. 24m. from the Beginning of γ ; and so for any other, as in the following Table.

M

Prob.

Stars Names.	Magni- f.	Longi- tude. D. M.	Latitude	Right Ascen. D. M.	Declina- tion. D. M.
<i>Pole Star, or North- Star</i> ———	2	II 26.05	66.30 N	08.00	87.35 N
<i>Left in Eridanus, Alcornar</i> ———	1	⌘ 10.55	59.55 S	21.15	58.55 S
<i>Whale's Jaw, Cetus</i>	2	♄ 10.30	12.37 S	42.02	05.00 N
<i>Bull's Eye, Aldebaran</i>	1	II 5.58	5.32 S	65.05	15.56 N
<i>Capella, or Auriga's left Shoulder</i> ———	1	II 18.02	22.52 N	74.07	45.41 N
<i>Orion's left foot, Regel</i>	1	II 13.00	31.10 S	75.21	08.33 S
<i>Orion's right Shoulder</i>	1	II 24.55	16.05 S	85.05	07.19 N
<i>Great Dog, Sirius</i> ———	1	♄ 10.19	39.32 S	98.17	16.21 S
<i>Little Dog, Procyon</i>	1	♄ 22.00	15.58 S	111.14	05.54 N
<i>Hydra's Heart, Al- phard</i> ———	1	♋ 23.28	22.24 S	138.31	7.29 S
<i>Lion's Heart, Regulus</i>	1	♋ 26.01	00.37 N	148.26	31.17 N
<i>Foot of the Crostiers</i> ———	2	♋ 08.08	52.45 S	183.05	61.31 S
<i>Virgin's Spike</i> ———	1	♍ 20.01	02.02 S	197.44	09.43 S
<i>Arcturus in Bootes</i> ———	1	♍ 20.24	30.57 N	210.48	20.39 N
<i>Bright Star of the Harp, Lyra,</i> ———	1	♌ 11.27	61.46 N	276.54	38.33 N
<i>South Fish, Womethaut</i>	1	♐ 29.59	21.05 S	340.35	31.03 S

Problem 22. *To find the Rising, Setting, and Culmination of a Star, at any Time, in any Latitude.*

The Rule. 1. Rectify the Globe and Hour Index, as in Problem 10.

2. Bring the Star (whose Rising you would know) to the East Side of the Horizon, and then the Index will point to the Time of its Rising: Also the Degree of the Horizon against the Star, is its Amplitude at Rising.

3. Bring the Star to the Brass Meridian, and the Index will shew the Time of its Culminating (or coming to the Meridian:) Also the Degree on the Brass Meridian, contained from the Horizon to the Star, is its Meridian Altitude.

4. Bring the Star to the West Side of the Horizon, and then the Index will shew the Time of its Setting: Also against the Star, (on the Horizon) is its Amplitude at Setting, which is ever the same Quantity as at Rising.

This

This is so easy to perform, and so often done in the Problems concerning the Sun, it needs no Example.

Problem 23. *To know at any Time what Stars are above the Horizon, either Rising towards the Meridian, or falling from it, towards their Setting; as also, what is their Latitude and Azimuth?*

The Rule. 1. Rectify the Globe, Hour Index, and Quadrant of Altitude, as before, in Problem 10.

2. Turn the Globe 'till the Hour-Index points to the given Time of the Day or Night; and there stay the Globe.

3. Then observe what Stars are even with the East Side of the Horizon, those are then rising; and all those that are between the Horizon and the East Side of the Meridian, are risen above the Horizon, and are rising towards the Meridian.

4. All those Stars near the Brass Meridian, are then near the Meridian of that Place; and those at the Brass Meridian, are then on the Meridian of that Place.

5. If the Quadrant of Altitude be put to any Star, it will shew it's Altitude at that Time and Place, and in the Horizon, the Quadrant shews it's Azimuth.

6. All those Stars on the West Side of the Meridian are falling from it, towards their Setting; those near the Horizon are Setting; and those below the Horizon are Set.

In a Word, let the Globe (by Help of a Magnetic Needle, or Compass, or otherwise) be set so, as the North Point of its Horizon may point to the true North in the Heavens, and the South point to the South; then imagine your Eye plac'd within the Globe at its Center, and that the Globe were transparent; or supposing a small round Hole through the Center of any Star, now your sight passing through it, will direct to the Star in the Heavens, correspondent to that on the Outside of the Globe.

This being mathematically well consider'd, will make the Use of the Globes easy, and very much conduce to the Knowledge of the Stars, a Thing not a little necessary in Navigation, but too much neglected by most Mariners.

Problem 24. *To find the Hour of the Night by the Altitude of a known Star.*

The Rule. 1. Rectify the Globe, Hour Index, and Quadrant of Altitude, as before, in Problem 10.

2. Turn the Globe and Quadrant of Altitude 'till you bring the Star against it's given Altitude in the Quadrant, and there stay them.

M 2

3. Then

3. Then will the Index shew the Hour required; and the Quadrant will cut the Horizon in the Star's Azimuth.

Note; If the Star you observe be on the East Side of the Meridian, then turn the Quadrant of Altitude on the East Side of the Brass Meridian of the Globe: And if on the West Side, turn the Quadrant also on the West Side.

Example. At London, December 12th, the Altitude of Regulus, or the Lyon's Heart, being 25d. 30m. Oriental, or on the East side of the Meridian: I demand the Hour of the Night?
Answer. According to the aforesaid Rule, the Hour is near 30m. after 10 at Night, and the Star's Azimuth 78d. 30m. South Easterly, or East by South nearest.

So much for the Use of the Globes, which is gone far beyond it's first designed Limit, occasioned by a constant Resolution to be plain.

And, by the way, Let me advise those who have not Convenience for, nor Ability to purchase Globes, and yet would know the Stars, that they may attain it with a pair of Hemispheres, wherein are all the Constellations; and each Star according to its Longitude and Latitude placed in them; such are made of near 20 Inches in Diameter, to fold in a Book, like a Sea-Chart, in four Leaves: They are projected on the Plain of the Ecliptic, or, as some say, on the Poles of the Ecliptic: So that in one Hemisphere (which is one Leaf) you have all the Constellations on the North Side of the Ecliptic, and in another all the Southern.

The Poles of the Ecliptic, is the Center of each Hemisphere, and the Margent going round them is the Ecliptic, being divided into the 12 Signs, and each Sign into 30 Degrees; each Degree being subdivided into Halves and Quarters: And Lines drawn from the Center (or Pole of the Ecliptic) to the Beginning of each Sign.

On one of those Lines are placed the Degrees of Latitude, and number'd from the Ecliptic with 10, 20, &c. to 90, at the Pole and Center of it.

By these Hemispheres any of the former Problems (wrought on the Cœlestial Globe) may be solved: As for Instance;

To find the Longitude, and Latitude of a Star.

The Rule. 1. Stretch out the Silk String (fastened in the Center for that Purpose) over the Center of the given Star, and it sheweth, or cutteth the Star's Longitude in the Ecliptic.

2. With

2. With a pair of Compasses, take the Distance from the Center of the Star to the Center of the Hemisphere; lay that Distance on the Scale of Latitude from the Center of the Hemisphere, and it will shew the Latitude required.

Example. *The Foot of the Crossiers, a Star of the second Magnitude in the Southern Hemisphere, between Robur Carolinum, and Centaurus: I demand it's Latitude and Longitude?*

1. Laying the like Silk String over the Star's Center, its cuts the Ecliptic in *Virgo* 8d. the Star's Longitude.

2. Take the Star's Distance from the Center of the Hemisphere, measure it on the Solstitial Colure, from the said Center, and it reacheth to 5 3d. 10m. the Star's Latitude South.

There are drawn in these Hemispheres, the Equinoctial, Tropics, Polar Circles, and Poles of the World; all which are described by their Names set to them: More Circles may be drawn, and are of Use in serving other Problems; which shall be shewed after the Problems in Astronomy.

CHAPTER VII.

Spheric Trigonometry, applied in Problems of Geography.

BEfore I treat of Great Circle Sailing, 'tis not amiss to discourse something in Geography; and for a more distinct Knowledge thereof, take these following Definitions and Problems. These Definitions are much the same as before, in Chapter 4. of *Mercator's Sailing*, in page 82.

Section I. *Geographic Definitions. Plate 5. Fig. 1.*

1. **T**HE Earth (on which we dwell) together with the Water, make one round Body or Globe, which is the Subject of Geography.

2. The Poles of the Earth, are two imaginary Points, directly opposite, upon the Surface of it; that in the North, called the North Pole; and that in the South, called the South Pole; As P and I. Plate 5. Fig. 1.

3. The Equator, or Line under the Equinoctial, is a Line drawn round the Globe, and lieth in the Middle between both Poles, cutting all Meridians at Right-Angles, and is a Great Circle, from which Latitude taketh its Beginning, and in which Longitude is reckon'd, as *EAQ*. Plate 5. Fig. 1.

4. Meridians, are Great Circles drawn thro' both Poles cutting the Equator at Right-Angles, as *PQI*, *PAI*, and *PMI*, answerable to them, are the North and South Lines drawn in any Chart.

5. **Parallels of Latitude** are less Circles drawn parallel to the Equator, through every Degree and Minute of the Meridian, between the Equator and each Pole, as *alt* and *Z * 't*, and are represented in any Chart, by the East and West Lines therein.

6. **Latitude**, is an Arch of a Meridian, contained between any Parallel and the Equator; from whence it is counted both Ways to each Pole, where it ends in 90 Degrees, which is the greatest Latitude.

7. **North Latitude**, is on that Side of the Equator towards the North Pole, and **South Latitude** towards the South Pole.

8. **Difference of Latitude**, is an Arch of a Meridian, and the nearest Distance between any two Parallels, and sheweth how far any Place is to the Northward or Southward of another Place, and never exceedeth 180 Degrees.

9. **Longitude**, is reckon'd in the Equator, round which, increasing to the Eastward, 'tis counted (by some) 'till it end (where it first began) in 360 Degrees, which is the greatest Longitude: Or, according to Mr. *Wakely*, in his *Mariner's Compass Rectified*, 'tis counted from the Meridian of *London*, increasing on both sides of it, Eastward and Westward, 'till it terminates in 180 Degrees, at the opposite Meridian.

10. **Longitude of a Place**, is an Arch of the Equator contained between the Meridian of that Place, and the first Meridian where Longitude taketh its Beginning, and counted (by the old Way) to the Eastward of the First Meridian, (but by the new Way) 'tis counted both Eastward and Westward from the Meridian of *London*; which in this Account is the Meridian, whence Longitude taketh its Beginning.

11. **Difference of Longitude**, is an Arch of the Equator, contained between the Meridians of any two Places, and never exceedeth 180 Degrees.

12. **The Distance of any two Places**, is an Arch of a Great Circle, passing thro' them, and never exceedeth 180 Degrees.

13. **The Angle of Position**, or the Angle of Situation of Places, is an Angle the Arch of a Great Circle passing over two Places, makes with the Meridian of one of them, and is not the Course leading from one to the other.

In finding the Distance of Places, there are three Cases: As (1.) when they differ only in Latitude; (2.) when they differ only in Longitude; (3.) when the two Places differ both in Latitude and Longitude; all which are performed by the following Problems.

Section

Section II. Geographic Problems.

Case 1. *Two Places differing only in Latitude, given; to find their Distance.*

Note 1. **T**WO Places under one Meridian, or bearing North and South from each other, or in one Longitude, are said to differ only in Latitude.

2. Two Places differing only in Latitude, the Difference of Latitude is the Distance required: In which there are two Varieties.

Variety 1. Problem 1. *Two Places both on the same Side of the Equator; that is, both in North, or both in South Latitude; to find their Distance?*

The Rule. Subtract the less Latitude from the greater, the Remainder (reduce into Leagues or Miles) is the Distance required.

Variety 2. Problem 2. *If one Place be on one Side of the Equator, the other on the other Side; that is, one in North Latitude, and the other in South Latitude; to find their Distance?*

The Rule. Add the two given Latitudes together, the Sum (reduce into Leagues or Miles) is the Distance required.

These are so easy, 'tis needless to give Examples, being the same you had in Chapter 3. Section 3. General Rule 2. in *Plain Sailing*, in page 58.

Case 2. *Two Places differing only in Longitude given; to find their Distance?*

Note; Two Places differing only in Longitude, lie East and West from each other, and are either in the Equator, or else in one Parallel of Latitude.

In this Case are two Varieties.

Case 2. Variety 1. Problem 3. *Two Places in the Equator, their Longitudes being given; to find their Distance?*

The Rule. 1. According to the old Way of counting the Longitude, subtract the less Longitude from the greater, the Remainder (if less than 180 Degrees) is the Distance required: But when 'tis more, subtract it from 360 Degrees, and this last Remainder is the Distance.

2. According to the new Way of counting the Longitude, in the *Mariner's Compass Rectified*, the Rule is thus;

If both Longitudes be East, or both West, subtract the less from the greater, the Remainder is their Distance: But when one Place is in East, and the other in West Longitude, add them, and the Sum (if it exceed not 180 Degrees) is the Distance

stance, and when it doth exceed 180 Degrees, subtract it from 360 Degrees, the Remainder is the Distance required, which is the same as in Chapter 4. Section 2. Problem 3. page 89. of *Mercator's Sailing*.

Case 2. Variety 2. Problem 4. *Two Places in one Parallel, or both in one Latitude, their Longitudes being given, to find their Distance.*

Example. *I demand the Distance between the Lizard, and Penguin Island in Newfoundland.*

	d.	m.		d.	m.
<i>Lizard</i>	}	Latitude	50 00 N.	Longit.	5 24 W.
<i>Penguin Island</i>					53 10 W.
Subtract from			90 00	Diff Long.	47 46
Rem is the Comp. Lat.			40 00		

These Places supposed both in the Latitude of 50d. 00m. North, whose Complement is 40d. 00m.

To delineate this Problem Stereographically on the Plain of the Meridian of the *Lizard*. *Plate 5. Figure 1.*

1. Describe the Circle ÆPQI , with a Chord of 60 deg or Half-tangent of 90 Degrees, and Quarter it, with the two Diameters or Right Circles PAI , and ÆAQ : Then is P the North Pole, I the South Pole, and ÆAQ the Equator.

2. By Problem 2. Case 2. Page 112. of Spheric Geometry, make the Angle ÆPN equal to 47d. 46m. (the Difference of Longitude) by drawing the Oblique Circle $\text{P} \odot \text{NI}$, with the Secant thereof.

3. Make PZ equal to 40d. 00m. (the Complement of the given Latitude) by Prob 6. Case 1. Page 116. of Spheric Geometry.

4. Through Z draw the Parallel Circle $\text{Z} \odot \text{lt}$ (by Problem 9. Case 2. in Page 121. of Spheric Geometry,) with the Tangent of 40d. 00m. (the Complement of the given Latitude) to cut the Oblique Circle $\text{P} \odot \text{NI}$ in $\odot$: Then NZ represents the *Lizard*, and $\odot$ *Penguin Island*, both in one Parallel of Latitude.

5. Then thro' Z and $\odot$, draw a great Circle, as is the Oblique Circle $\text{Z} \odot \text{C}$, and it's done, for $\text{Z} \odot$ on the Oblique Circle is the Distance required, which is measured by Problem 7. Case 3. in Page 118. of Spheric Geometry.

To find their Distance by Trigonometry, 'tis to be noted; That in the Oblique Spheric Triangle $\text{ZP} \odot$. *Plate 5. Fig. 1.*

1. The Side ZP equal to $\text{P} \odot$ is the Comp. of the Lat. 40d. 00m.

2. The Angle $\text{ZP} \odot$ the Difference of Longitude—47d. 46m.

3. The

3. The Side $Z\odot$ the Distance of the two Places; which to find, let fall the Perpendicular PB (by drawing an Oblique Circle with the Secant of $23^d. 53m.$ half the (given) Difference of Longitude to cut the Oblique Circle $Z\odot$ (in B) and it divides the Oblique-Spheric-Triangle into two equal Rectangle-Spheric-Triangles PBZ and $PB\odot$, in each the Hypotenuse, and one Angle is given.

1. The Angle ZPB equal to $BP\odot$, is half the Difference of Longitude, $23^d. 53m.$

2. The Leg ZB equal to $B\odot$, is half the Distance required.

Therefore the Proportion by Chapter 5. Section 4. Problem 2. Case 4. in page 136. of Rectangular Spheric Trigonometry, is thus;

As Radius, is to the Sine Complement of the Latitude; so is the Sine of half the Difference of Longitude, to the Sine of half their Distance required. But in short thus,

As Radius .. S. Hypot. PZ :: S. Angle ZPB .. S. Leg ZB $\frac{1}{2}$ the Dist.

As S. $90^d.$.. S. $40^d. 00m.$:: S. $23^d. 53m.$.. S. $15^d. 05m.$

Which being doubled, makes the Distance $30^d. 10m.$ or 1810 Minutes, which is the Distance between the *Lizard* and *Penguin Island*, in the Arch of a Great Circle.

Problem 5. To find how many Miles or Minutes of the Equator, make a Degree of Longitude in any Parallel of Latitude.

The Rule, or Proportion is;

As Radius, is to the Sine Complement of the Latitude;

So is 60 Miles or Minutes a Degree of the Equator, to the Miles or Minutes of the Equator, which make a Degree of Longitude in the Parallel required.

Example. How many Miles will answer to make a Degree of Longitude, in the Latitude of $51^d. 32m.$

As Radius .. S. c. Lat. :: a deg. in the Equa. .. a deg. in the Par.

As S. $90^d.$.. S. $38^d. 28m.$:: 60 Minutes .. Min. 37.32 Parts.

The Miles of the Equator that make a Degree of Longitude in the Latitude of $51^d. 32m.$

Case 3. Two Places differing both in Latitude and Longitude, their Latitudes and Longitudes being given, to find their Distance.

Note, In this Case are three Varieties.

Variety 1. Problem 6. One Place in the Equator, and the other towards either of the Poles.

Example. Suppose the *Lizard*, and the Entrance of the River *Amazones*, their Latitudes and Longitudes being as followeth: I demand their Distance?

Lizard

		d. m.		d. m.
<i>Lizard</i>	} Lat.	{ 50.00 } N.	Long.	{ 5 24 W.
<i>Amaz. River</i>				
				{ 48.04 W.

Difference of Longitude ————— 42.40

To delineate it Stereographically on the Plain of the Meridian of the *Lizard*. Plate 5. Fig. 1.

1. The Circle being described, and quarter'd as before, in Problem 4. make ÆZ on the Primitive Circle equal to 50d. 00m. the Latitude of the *Lizard*, by Problem 6. Case 1. in page 116. of *Spheric Geometry*.

2. By the same Problem, Case 2. lay 42d. 40m. the given Difference of Longitude, on the Right Circle ÆAQ (which is the Equator) that is, take the Half Tangent 42d. 40m. the contrary Way, and lay it from Æ to N .

3. Then through Z and N draw a Great Circle, as is the Oblique Circle ZNC , and 'tis done: For ZN (measured by Problem 7. Case 3. in page 118. of *Spheric Geometry*) is the Distance required.

But to find their Distance by Trigonometry. Observe,

That in the Rectangle Spheric Triangle ZÆN . Plate 5. Fig. 1.

1. The Leg ZÆ , is the Latitude of the *Lizard*, 50d. 00m.

2. The Leg ÆN , the Difference of Longitude between them, equal to 42d. 40m.

3. The Hypotenuse ZN , their Distance is required, to find which (by Chapter 5. Section 4. Problem 5. Case 14. in page 140. of *Rectangular Spheric Trigonometry*) the Proportion is thus;

As Radius, is to the Sine Comp. of the *Lizard* Latitude;

So is the Sine Complement of their Difference of Longitude, to the Sine Complement of their Distance required. But in short thus:

Radius .. S.c. Leg ZÆ : : S.c. Leg ÆN .. S.c. Hyp. ZN the Dist.
 S. 90d. .. S. 40d. 00m. : : S. 47d. 20m. .. S. 28d. 12m. whose Complement is 61d. 48m. equal to 3708 Minutes, is the Distance between the *Lizard* and River *Amazones*.

Case 3. Variety 2. Problem 7. Two Places lying towards one of the Poles; that is, both in North Latitude, or both in South Latitude, their Latitudes and Longitudes being given; to find their Distance.

Example. I demand the Distance between the *Lizard* and Island *Barbadoes*?

Lizard

Lizard } Lat. { 50.00 } N. Long. { 5.24 W.
I. Barbadoes } { 13.00 } { 57.54 W.

Difference of Longitude ————— 52.30

To delineate this Stereographically, on the Plain of the Meridian of the *Lizard*.

1. Having described the Primitive Circle, and quarter'd it as before, make the Angle ÆPM , (by Problem 2. Case 2. in page 112. of *Spheric Geometry*) equal to 52d. 30m. the given Difference of Longitude, by drawing the Oblique Circle PMI , with the Secant thereof.

2. On the Primitive Circle (by Prob. 6. Case 1. in Page 116. of *Spheric Geometry*) make PZ equal to 40d. 00m. the Complement of the *Lizard's* Latitude, by laying the Chord thereof from P to Z .

3. Draw the Parallel Circle aLl (by Prob. 9. Case 2. in page 121. of *Spheric Geometry*) at 13d. 00m. (*Barbadoes* Latitude) Distance from the Right Circle ÆAQ , the Equator, to cut the Oblique Circle PMI in L .

4. Then thro' Z and L , draw a Great Circle, as the Oblique Circle ZLNC , and 'tis done; for ZL (measured by Prob. 7. Case 3. in page 113. of *Spheric Geometry*) is the Distance required.

But by Spheric Trigonometry, to find their Distance, it is to be noted.

That in the Oblique Spheric Triangle ZPL . Plate 5. Fig. 1.

1. The Side PZ is the Comp. of the *Lizard*, Lat. 40d. 00m.

2. The Side PL is the Comp. of *Barbadoes* Lat. 77d. 00m.

3. The Angle ZPL their Difference of Longit. 52d. 30m.

4. The Side ZL their Distance required.

To find which (by Chap. 5. Section 5. Problem 9. Case 8. in page 145. of *Spheric Trigonometry Oblique*) The Rule is,

First, As Radius, is to the Sine Complement of the Difference of Longitude; So is the Tangent Complement of the greater Latitude, To the Tangent of a Fourth Arch.

Which being subtracted from the Complement of the less Latitude, when the Difference of Longitude is less than 90 Degrees; but when more than 90 Degrees from its Supplement to 180 Degrees, the Remainder is the Residual Arch. Then.

Secondly, As the Sine Complement of the Fourth Arch afore-said, is to the Sine Complement of the Residual Arch; so is the Sine of the greater Latitude, to the Sine Complement of the

the Distance required. But in short, as follows ;

As Radius .. S.c.Angle ZPL : : T. Side ZP .. T. 4th Arch,

As S. 90d. .. S. 37d. 30m. : : T. 40d. 00m. .. T. 27d. 04m. which
being subtracted from the Side PL 77d. 00m. the

Remainder is the Residual Arch ————— 49d. 56m.

Then again say,

As S.c. 4th Arch .. S.c. Resid. Arch : S.c. Side ZP .. S.c. Side ZL.

As S. 62d. 56m. .. S. 40d. 04m. : : S. 50d. 00m. .. S. 33d. 37m.

Whose Complement 56d. 23m. or 3383 Minutes, is the Distance from the Lizard to Island Barbadoes in the Arch of a Great Circle.

Case 3. Variety 3. Problem 8. Two Places, one in North Latitude, the other in South Latitude ; their Latitudes and Longitudes given ; to find their Distance.

Example. I demand the Distance from Cape Cod in New England, to Cape Bona Esperance, or Cape of Good Hope in Africa ?

	d. m.		d. m.
Cape Cod	} Lat. { 42 10 N. }	} Longit. { 67 45 W. }	
C. Bona Esp.			
	{ 34 25 S. }	{ 17 10 E. }	

Difference of Longitude is ————— 84 55

To delineate it Stereographically on the Plain of the Meridian of Cape Cod. Plate. 5. Fig. 1.

1. The Primitive Circle being described, and quarter'd as before directed, make (by Problem 2. Case 2. in page 112. of *Spheric Geometry*) the Angle $\angle EPM$ equal to 84d. 55m. the given Difference of Longitude, by drawing the Oblique Circle PMI with the Secant thereof : But the Secant is so large that 'tis not easy to do ; therefore in such Cases, lay it on the Right Circle $\angle EMAQ$, the Equator (by Prob. 6. Case 2. in page 116. of *Spheric Geometry*) from $\angle E$ to M, that is, from the Scale of Half-tangents the contrary way ; and laying a Bow screw'd up to the three Points P, M, and I, draw the Oblique Circle by it.

2. On the Primitive Circle, (by Problem 6. Case 1. in page 116.) make PZ equal to 47d. 50m. the Complement of Cape Cod's Latitude.

3. Draw the Parallel Circle $\angle Dlt$ (by Problem 9. Case 2. in page 121.) at 34d. 25m. Cape Bona Esperance Lat. (or Distance from the Right Circle $\angle EAQ$ the Equator) to cut the Oblique Circle PMI, in D, representing Cape Bona Esperance.

4. Thro' Z and D, draw a Great Circle, as the Oblique Circle ZDC, and 'tis done : For ZD (measured by Problem 7. Case 3. in page 118. of *Spheric Geometry*) is the Distance requir'd.

By

By *Spheric Trigonometry*, to find their Dist. it's to be consider'd,
That in the Oblique Spheric Triangle ZPD, *Plate 5. Fig. 1.*

1. The Side PZ is the Comp. of *Cape Cod's* Latit. 47d. 50m.
2. The Side PD the distance of *Cape Bona Esperance* from the North Pole, or it's Latitude added to 90d. that is 124d. 25m.
3. The Angle DPZ their Differ. of Longitude 84d. 55m.
4. The Side ZD their Distance required, which is thus found.

By Chapter 5 Section 5. Problem 9. Case 8. in page 145, of *Spheric Trigonometry Oblique*, the Proportions are these.

First, As Radius, is to the Sine Complement of their Difference of Longitude; so is Tangent Complement of one of the given Latitudes, to the Tangent of a Fourth Arch. Then,

If the Difference of Longitude be less than 90d. subtract the Fourth Arch out of the other Latitude, added to 90d. but if the Diff. Long. be more than 90d. from the Supplement thereof to 180d. the Remainder is the Residual Arch. And then,

Secondly; As the Sine Complement of the Fourth Arch, is to the Sine Complement of the Residual Arch; so is the Sine of the Latitude first taken, to the Sine Complement of the Distance required. But in short thus;

As Radius .. S.c. Ang. DPZ: : T.Side PZ .. T. 4th Arch.
As S. 90d. .. S. 05d. 05m. : : T. 47d. 50m. .. T. 5d. 35m. which
being subtracted from the Side PD ——— 124d. 25m.

The Remainder is the Residual Arch ——— 118d. 50m.

Then again say,

S.c. 4th Arch .. S.c. Residual Arch: : S.c. Side PZ .. S.c. Side ZD
S. 84d. 25m. .. S. 28d. 50m. : : S. 42d. 10m. .. S. 18d. 59m.
Which added to ————— 90d. 00m.

The Sum is the Side ZD their Distance ——— 108d. 59m.

Or 6539 Minutes is the Distance from *Cape Cod* to *Cape Bona Esperance*, in the Arch or a Great Circle.

CHAPTER VIII.

Of the third Part of Navigation, or the Doctrine of Spheric Trigonometry, applied in Great-Circle-Sailing.

GREAT Circle-Sailing, as it's the exactest, so it's the most difficult, and hardly possible for a Ship exactly to sail by;

by ; yet it may be of good Advantage to keep conveniently near it, especially in a parallel (or East and West) Course.

2. *Great Circle Sailing*, is Sailing by, or upon the Arch of a Great Circle, passing through the two Places.

3. In Great Circle Sailing, are but three Cases, *viz.*

(1.) When two Places differ only in Latitude.

(2.) When they differ only in Longitude ; and,

(3.) When they differ both in Latitude and Longitude.

Case 1. *Two Places differing only in Latitude, their Latitudes given ; to find their Distance.*

1. This is the same with Chapter 7. Section 2. Problem 1, and 2. in Page 183 of Geography, to which I refer the Reader for finding their Distance, and so pass to

Case 2. *Two Places differing only in Longitude, the Latitude and Longitude being given ; to find their Distance in the Arch of a Great Circle, and all that is requisite in Great Circle Sailing.*

1. This is the same with Chapter 7. Section 2. Problem 3, and 4. in Pages 183, and 184, of Geography, to find their Distance.

2. These Places are either in the Equator, or in one Parallel, and lie East and West from each other ; but their Distance in that Parallel, is not their nearest Distance, the Parallel being a *Less Circle*.

3. The Distance in the Parallel hath been shewed in Chapter 4. Section 3. Problem 10. of *Mercator's Sailing*, in Page 100 ; and their Distance in the Arch of a Great Circle is found by Chapter 7. Section 2. Problem 4. in Page 184 of Geography. But the Angles of Position made by the Great Circle, and it's Latitude, and Longitude at any assign'd Portion, together with the Course, and Distance from Place to Place, so assign'd in it, is the Work now.

Case 2. Problem 1. *Suppose the Lizard, and Penguin Island, both in the Latitude of 50d. 00m. North, whose Difference of Longitude is 47d. 46m. (as before in Problem 4. in Page 184 of Geography) I demand the Angles of Position ? The Great Circle's Distance between them ? The Latitude of the Arch at every 5 Degrees Difference of Longitude ? And the Course, and Distance of each of them according to Mercator ?*

↓

This

This Problem is delineated by the Directions in Problem 4. of Geography, in page 184. And observe that,

In the Oblique Spheric Triangle APC. *Plate 5. Fig. 2.*

1. A represents the *Lizard*.
2. C *Pengwin* Island.
3. The Side PA equal to PC, the Complement of the Latitude of each Place, 40 Degrees.
4. The Angle APC, the Difference of Longitude 47d. 46m.
5. The Angle CAP equal to ACP, the Angle of Position at each Place.
6. The Side AC, the Great Circle's Distance between them.

First, For the Angle CAP equal to ACP, the Angles of Position at the two Places.

Draw the Perpendicular PB, (as was taught in Problem 4. of Geography, in page 185.) which divideth the Oblique Triangle APC, into two equal Rectangle Spheric Triangles ABP, and CBP, in each, the Hypotenuse and one Angle are given. That is,

1. The Hypotenuse PA equal to PC, the Complement of their Latitude 40 Degrees.
2. The Angle BPA, equal to BPC, half their Difference of Longitude 23d. 53m.
3. The Angle BAP, equal to BCP, the Angle of Position at each Place.
4. The Leg AB, equal to BC, half the Great Circle's Distance.
5. The Leg BP, the Complement of the Arch's greatest Latitude.

And by Chapter 5. Section 4. Problem 2. Case 6. of Spheric Trigonometry Rectangular, in page 137. the Proportion is thus;

As Radius, is to the Sine of the Latitude; so is the Tangent of half the Difference of Longitude, to the Tangent Complement of the Angle of Position at each Place. That is;

As Radius .. S.c. Hyp. AP : : T. Angle APB .. T.c. Angle BAP.
As .. S. 50d. 00m. : : T. 23d. 53m. .. T. 18d. 44m.

Which being subtracted from _____ 90d. 00m.

Remainder is the Angle of Position at each Place, 71d. 16m.

Secondly, The Leg AB, equal to BC, is found (by Problem 4. of Geography, in page 185.) 15d. 05m. and therefore the Side AC is 30d. 10m. or 1810 Minutes, the Distance of the two Places in the Arch of a Great Circle.

Thirdly, To find the Latitude by which the Arch shall pass at every 5 Degrees Difference of Longitude from A, representing the *Lizard*; these Things following must be observed:

First,

First, Find the Leg BP, the Complement of the greatest Latitude by which the Arch (of the great Circle) doth pass; and that by Chapter 5. Section 4. Problem 2. Case 5. of Spheric Trigonometry Rectangular, in page 137. is thus;

As Radius, is to the Sine Complement of half the Difference of Longitude :

So is the Tangent Complement of the given Latitude, to the Tangent Complement of the Arch's greatest Latitude: In short thus;

As Radius .. S.c. Angle BPA :: T. Hypot. PA .. T.c. Leg BP.

As S. 90d. .. S. 66d. 07m. :: T. 40d. 00m. .. T. 37d. 30m.
Which being subtracted from ————— 90d. 00m.

Remainder is the Arch's greatest Latitude ————— 52d. 30m.

Secondly, To find the Latitude by which the Arch of the Great Circle passes (at every 5 Degrees of Longitude) from A, draw Meridians from P, as Pd, Pe, Pf, &c. which may most easily be done Gnomonically, being then Right Lines, and that is thus;

The Gnomonic Projection. Plate 5. Fig. 3.

1. Make the Angle APC equal to 47d. 46m. the Difference of Longitude between the two given Places.

2. Make PA, and PC, each equal to the Tangent of 40d. 00m. the Complement of the given Latitude.

3. Draw the Line AC, which represents the Arch of a great Circle between them.

4. Let fall the Perpendicular PB, which being measured on the Scale of Tangents, is 37d. 30m. the Complement of the Arch's greatest Latitude.

5. Then draw Lines from P, each 5 Degrees distance from A, as Pd, Pe, Pf, Pg, Ph, Pi, Pk, Pl, and Pm; which are Meridians, and each 5 degrees of Longitude from A, the *Ligard*.

6. Measure Pd, Pe, Pf, &c. on the Scale of Tangents, and it sheweth the Complements of the Latitudes of the Arch, at the respective Places d, e, f, &c.

These are found (by Spheric Trigonometry) after this manner: The several prick'd Lines Pd, Pe, &c. are so many Hypotenuses, to as many Rectangular Spheric Triangles, which have one common Leg BP, the Complement of the Arch's greatest Latitude.

Now in each of these Rectangular Spheric Triangles, there is given a Leg, and its adjacent Angle, to find the Hypotenuse; that is, in the Triangle dBP, there is given the Leg BP, and Angle BPd; to find the Hypotenuse Pd, and so in all the rest.

And the several Angles BPd , BPe , &c. are found by a continual Subtraction of 5 Degrees from the Angle BPA 23d. 53m. half the Difference of Longitude, till the Remainder be less than 5 Degrees, which being taken out of 5 Degrees, and to this last Remainder add 5 Degrees successively 'till the Sum exceed not 23d. 53m. That is ;

	d.m.		d.m.
From the Angle BPA	23.53	Then to the Angle BPh	01.07
Subtract the Ang. APd	5.00	Add the Angle = hPi	05.00
Remain. is Ang. $\left\{ \begin{array}{l} BPd \\ BPe \\ BPf \\ BPg \end{array} \right.$	$\left\{ \begin{array}{l} 18.53 \\ 13.53 \\ 08.53 \\ 03.53 \end{array} \right.$	Sum is the Angle $\left\{ \begin{array}{l} BPi \\ BPk \\ BPl \\ BPm \end{array} \right.$	$\left\{ \begin{array}{l} 06.07 \\ 11.07 \\ 16.07 \\ 21.07 \end{array} \right.$
Wich Subtract from	05.00	These Angles are called Ver-	
Is the Angle BPh	= 01.07	tical Angles, or Angles at the	
Pole.			

Then find (by Chapter 5. Section 4. Problem 3. Case 9. of Spheric Trigonometry Rectangular, in pages 137, and 138) the several Latitudes of the Arch, which are by this Proportion.

As Radius, is to the Sine Complement of the Vertical Angle ;
So is the Tangent of the Arch's greatest Latitude, to the Tangent of the Arch's Latitude at the respective Places. Or,
As Radius .. S.c. BPd , BPe , &c. :: T.c. Leg BP .. T.c. Pd , Pe , &c.
As S. 90d. .. S. 71d. 07m. :: T. 52d. 30m. .. T. 50d. 58m. Lat. at d.

76 07	_____	51 41	} Latitude at $\left\{ \begin{array}{l} e \\ f \\ g \\ h \end{array} \right.$
81 07	_____	52 10	
86 07	_____	52 26	
88 53	_____	52 30	
83 53	_____	52 21	} $\left\{ \begin{array}{l} i \\ k \\ l \\ m \end{array} \right.$
78 53	_____	51 59	
73 53	_____	51 23	
68 53	_____	50 34	

So that by the *Gunter*, the Extent from the Sine of 90 degrees, to the Sine of 71d. 07m. will reach from the Tangent of 52d. 30m. to Tangent 50d. 58m. And the Extent from Sine 90d. to Sine 76d. 07m. will reach from Tangent 52d. 30m. to Tangent 51d. 41m. Also from Sine 90d. to Sine 81d. 07m. reacheth from Tangent 52d. 30m. to Tangent 52d. 10m. and so on for the rest.

But by Logarithms it may be thus contracted ; because the

N

First

First and Third Terms in each Proportion are the same, and Radius being the First, it follows.

That to the Tangent of the Arch's greatest Latitude, add the Sine Complement of each Vertical Angle, and from their Sum abate Radius, the Remainder is the Tangent of the Arch's Latitude at each Place required. As for Example.

d. m.			
Ar. greatest Lat.	52.30	Tang.	10.115019
Comp. Vertical Angles.	71.07	Sine	9.975974
			10.090993
	76.07	Sine	9.987124
			10.102143
	81.07	Sine	9.994759
			10.109778
	86.07	Sine	9.999002
			10.114021
	88 53	Sine	9.999917
			10.114939
	83.53	Sine	9.997520
			10.112539
	78.53	Sine	9.991774
			10.106793
	73.53	Sine	9.982587
			10.097606
	68.53	Sine	9.969811
			10.084830
		Tang.	50.34
			50.58
			51.41
			52.10
			52.26
			52.30
			52.21
			51.59
			51.23

Latitude of the Arch at

d
e
f
g
h
i
k
l
m

Thirdly, To find the Course and Distance of the aforefaid Places, having now the Latitude and Longitude of them; this is done by Chapter 4. Section 3. Problem 2. of *Mercator's Sailing*, in page 93.

As for Example. To find the Course and Distance from A to d.

There is given the Latitude of A 50d. 00m. North, and of d, 50d. 58m. North, with their Difference of Longitude 5d. or 300 Minutes West.

Their

Their Meridional Difference of Latitude (by the Table of Meridional Parts, in Pages 310, and 314) is 92 Minutes; Therefore,

For the Courses, the Proportion is ;

As Merid. Diff. Lat. .. Diff. Long. :: Radius .. T. of the Course
As 92 Minutes .. 300 Min. :: T. 45d. 1 .. S. 73d. 07m. N.
Westerly from A to d is the first Course.

For the Distances, the Proportions are,

As S. c. Course .. Diff. Lat. :: Radius .. Distance.

As S. 16d. 53m. .. 58 Min. :: S. 90d. .. 200 Min. from A to d.

After the same manner find the Courses and Distances from d to e, from e to f, &c. as follows.

For the Courses, the Proportions are ;

			d. m.	
As 69 Min. .. 300 Min. :: T. 45d. ..			T. 77.02	NW. from d to e.
47	_____	_____	81.06	from e to f.
26	_____	_____	85.02	from f to g.
6	_____	_____	88.46	NW. from g to h.
14	_____	_____	87.15	S. W. from h to i.
37	_____	_____	83.08	from i to k.
57	_____	_____	79.14	from k to l.
78	_____	_____	75.26	from l to m.
As 53 Min. .. 166 Min. :: T. 45d. ..			T. 72d. 18m	SW. from m to C

For the Distances, the Proportions are,

As S. 12d. 58m .. 43 Min :: S. 90d. ..			192 Min.	from d to e.
8d. 54m .. 29	_____	_____	187	from e to f.
4d. 58m .. 16	_____	_____	185	from f to g.
1d. 14m .. 04	_____	_____	186	from g to h.
2d. 45m .. 09	_____	_____	187	from h to i.
6d. 52m .. 22	_____	_____	184	from i to k.
10d. 46m .. 36	_____	_____	193	from k to l.
14d. 34m .. 49	_____	_____	194	from l to m.
17d. 42m .. 34	_____	_____	112	from m to C.

Which place orderly as in the Table following.

N 2

Places

Places	Places Latitudes.	Mercator's Parts.	Mer. Diff. Lat.	Difference of Longi- tude.	Diff. of La- titude	Courses from Place to Place.	Distances of Places.
	m.	Min.	Min.	D.	m. Min.	d. m.	Min.
A	50.00	3474					
a	50.58	3566	92	5 or 300	58	N 73.07 W	200
c	51.41	3635	69	5 or 300	43	N 77.02 W	192
e	52.10	3682	47	5 or 300	29	N 81.06 W	187
g	52.26	3708	26	5 or 300	16	N 85.02 W	185
i	52.30	3714	6	5 or 300	04	N 88.46 W	186
k	52.21	3700	14	5 or 300	09	S 87.15 W	187
l	51.59	3663	37	5 or 300	22	S 83.08 W	184
m	51.23	3606	57	5 or 300	36	S 79.14 W	193
n	50.34	3528	78	5 or 300	49	S 75.26 W	194
C	50.00	3474	54	2.45 or 166	34	S 72.18 W	112
The whole Distance is ——— 1820							

But in regard, most of the Courses in the Table are so near the West, you may sail WNW. 927 Min. until you are in the Latitude of 56d. 00m. North; and then WSW. 927 Min. farther, you will arrive at the Port desired.

By this means you alter the Latitude 6d. which is considerable, in respect of the Benefit of Observation, besides the Distance (this way) is but 44 Minutes more than that of the Great Circle, and not above 12 Minutes more than the Parallel or West Distance; which is evident, if you compare Chap. 4. Sect. 3. Problem 10. of *Mercator's Sailing*, in page 101. with this.

Case 3. *Two Places differing both in Latitude and Longitude; their Latitudes, and Longitudes being given: to find their Distance in the Arch of a Great Circle, and all that is required in Great Circle Sailing.*

Note; When two Places differ both in Latitude and Longitude, they lie neither in one Parallel, nor under one Meridian; of which here are three kinds, viz. (1.) one Place under the Equator, and the other in North, or South Latitude. (2.) Both Places in North, or both in South Latitude: And (3.) One Place in North Latitude, and the other Place in South Latitude.

These

Plate 5. Fig. 5. Fig. 1.

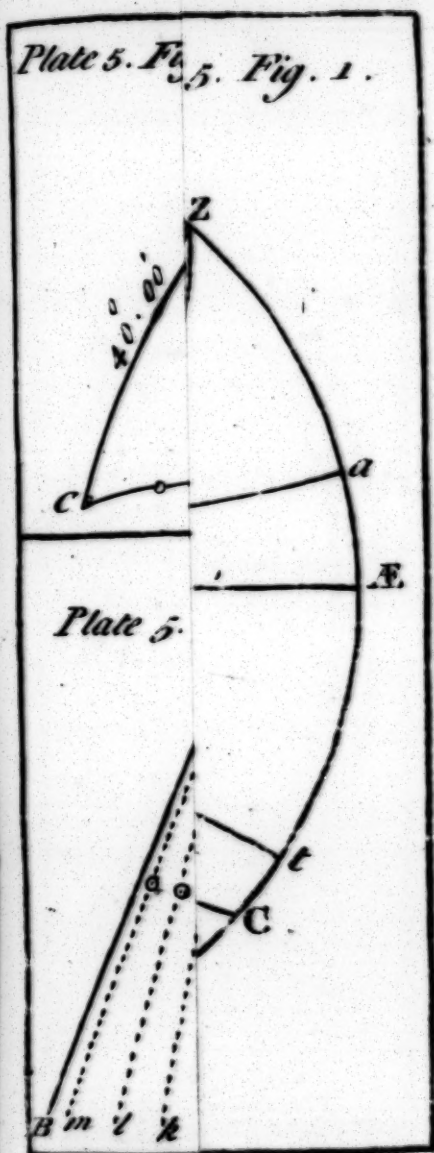


Plate 5. Fig. II

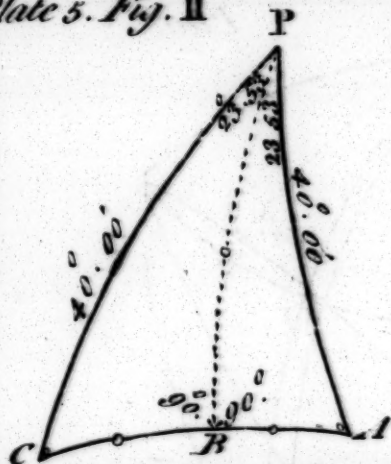
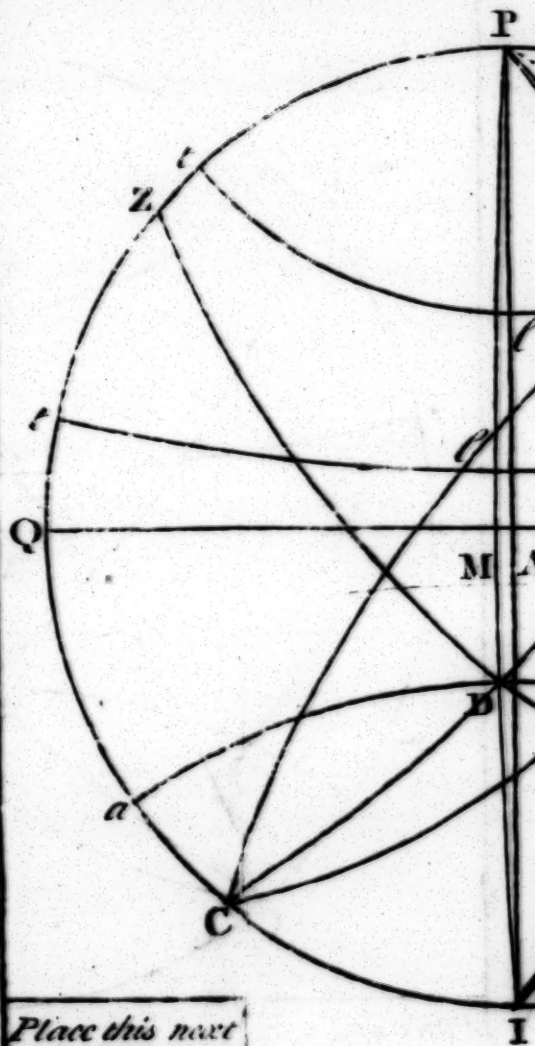
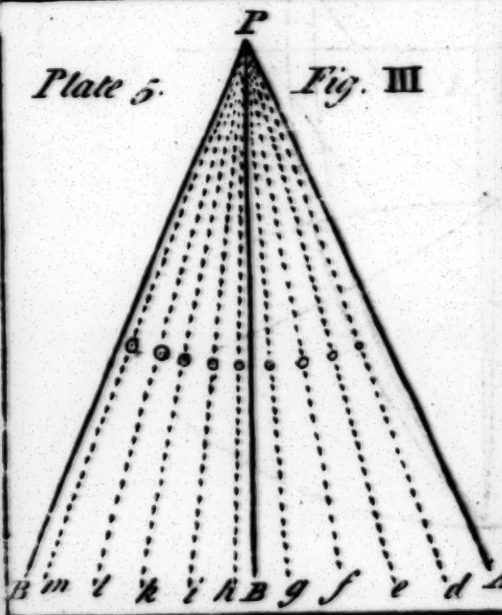
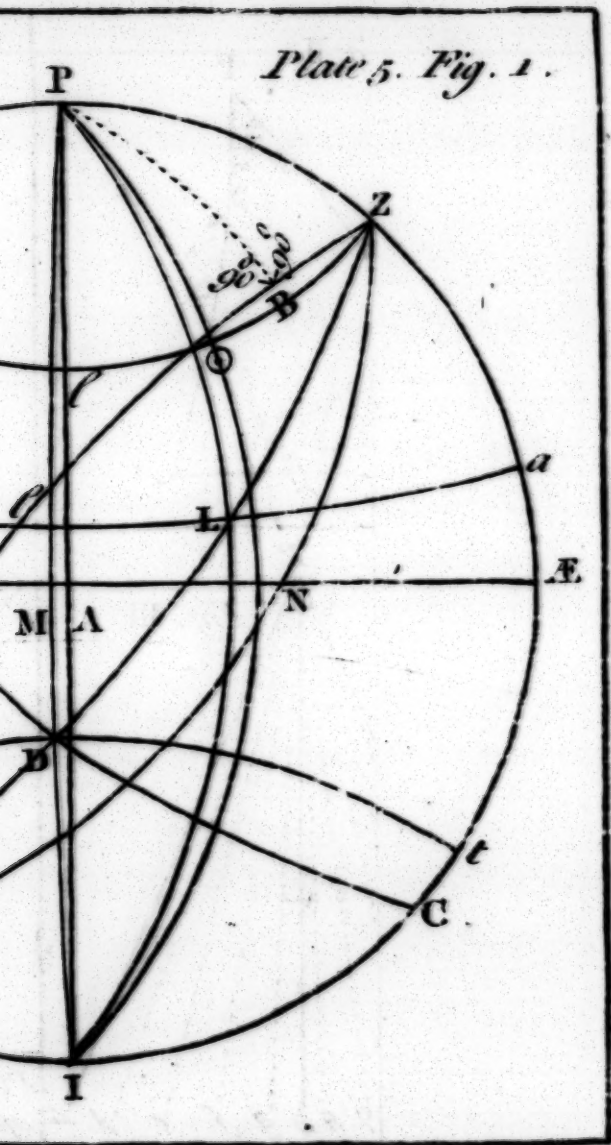


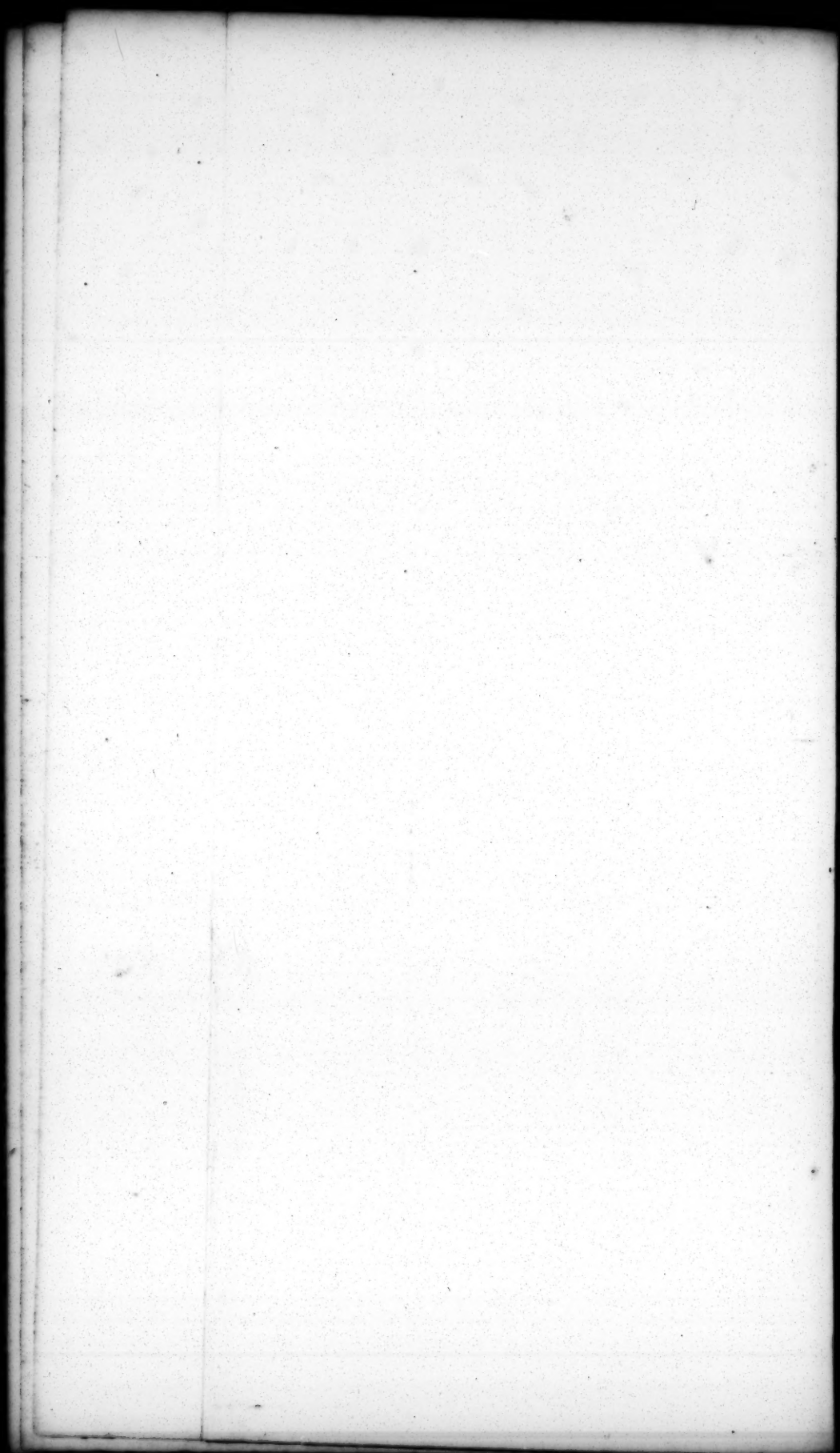
Plate 5. Fig. III



Place this next
after Pag. 196.

Plate 5. Fig. 1.





These three kinds of Places, differing both in Latitude and Longitude; how to find their Distance in the Arch of a Great Circle, hath been shewed in Chap. 7. Section 2. Case 3. Problem 6, 7, and 8, of *Geography*, in pages 185, 186, 187 and 188. But to find the Angles of Position, and what else is requisite in *Great-Circle-Sailing*, is the Work of the three following Problems.

Case 3. The first kind, *One Place under the Equator; the other in North, or South Latitude: As for Example.*

Problem 2. *Suppose the Lizard, and the Entrance of the River Amazones; I demand the Angles of Position? the great Circle's Distance between them? The Latitude of the Arch at every 10 Degrees Difference of Longitude? with the Course, and Distance of each of them, according to Mercator?*

The Latitude, and Longitude of these Places, supposed to be as follows

	d. m.		d. m.
Lizard — } Latitude {	50 00	Longitude {	5.24 W.
Amaz. River }	00.00	}	48.04 W.

Their Difference of Longitude ————— 42.40 W.

This Problem is delineated by the Directions in Problem 6. of *Geography*, in page 186. And here Note; That,

In the Rectangle Spheric Triangle ZÆN. Plate 6. Fig. 1.

1. Z represents the *Lizard*.

2. N the Entrance of *Amazgon* River.

3. The Leg ZÆ the Latitude of the *Lizard* 50d. 00m.

4. the Leg ÆN their Difference of Longitude 42d. 40m.

5. ÆZN the Angle of Position at the *Lizard*.

6. ÆNZ the Complement of the Angle of Position at *Amazones*, in the Equator.

7. The Hypotenuse ZN, the Great Circle's Distance between them.

For the Angles ÆNZ, or ÆZN (by Chapter 5. Section 4. Problem 5. Cases 13 and 14. of *Spheric Trigonometry Rectangular*, in pages 139 and 140, the Proportions are these;

As Radius, is to the Sine of the Latitude; So is the Tangent Complement of the Difference of Longitude, to the Tangent Complement of the Angle of Position at the Place having Latitude, That is,

As Radius .. S. Leg ÆZ :: T.c. Leg ÆN .. T.c. Angle ÆZN .

As S 90d. .. S. 50d. 00m. :: T. 47d. 20m. .. T. 39d. 44m.

Which subtract from _____ 90d. 00m.

Rests the Angle of Position at the *Lizard* — 50d. 16m.

And again,

As Radius is to the Sine of the Difference of Longitude ; So is the Tangent Complement of the *Lizard's* Latitude, to the Tangent of the Angle of Position at the Place in the Equator ; That is,

As Radius .. S. Leg ÆN :: T.c. Leg ÆZ .. T.c. Angle ÆNZ .

As S. 90d. .. S. 42d. 40m. :: T. 40d. 00m. .. T. 29d. 38m. the Angle of Position at *Amazones*, which sub. from 90d. 00m.

Rests the Angle ÆNZ — 60d 22m.

For the Hypotenuse ZN the Great Circle's Distance between them that's found (by Chapter 7. Section 2. Case 3. Problem 6. of *Geography* in pages 185, and 186) to be 61d. 48m. or 3708 Minutes.

To find the Latitude by which the Arch shall pass, at every 10 Degrees Difference of Longitude, from Z representing the *Lizard*, observe the following *Stereographic* Projection on the Plane of the Equator. *Plate 6. Fig. 1.*

1. Describe the Primitive Circle, on the Center P , which represents the Pole of the World, through it draw the Right Circle PZÆ , representing the Meridian of the *Lizard*, and from the Half-Tangents lay 40d. the Complement of it's Latitude from P to Z .

2. On the Primitive Circle lay 42d 40m. the Difference of Longitude from Æ to N ; also lay 10 deg. from Æ to f , from f to g , and so on to i .

3. Through Z representing the *Lizard*, and N the Entrance of *Amazones* River, draw a Great Circle, as ZN .

4. Draw the Right Circles Pf , Pg , Ph , and Pi ; which are Meridians, and cut the Arch ZN in a , b , c , and d , the respective Places whose Latitudes are required.

5. Measure af , bg , ch , and di , on the Scale of Half-Tangents, (the contrary way) and it sheweth the Latitude of the Arch at those Places : and to find them,

By Spheric Trigonometry.

The several Right Circles af , bg , &c. are so many Perpendiculars to as many several Rectangle Spheric Triangles, which have one common Angle ÆNZ , the Complement of the Angle of Position at that Place, which is in the Equator.

Now

Now in each of these Rectangle Spheric Triangles, there is given a Leg, and it's adjacent Angle, to find the other Leg, which is the Leg opposite to the given Angle; that is, in the Triangle a f N, there is given the Leg f N, and Angle a N f, to find the Leg a f, and so in all the rest of the Triangles.

And the several Legs N f, N g, &c. are found by a continual Subtraction of 10 Degrees from the Difference of Longitude, till the Remainder be less than 10 Degrees. The Remainders I call Vertical Arches, and are thus found.

		d.m.	Then (by Chapter 5. Section 4. Problem 3. Case 7. of Spheric Trigonometry Rectangular, in pages 137 and 138) to find the several Latitudes of the Arch, the Proportion is thus,
From the Arch	—	ÆN 42.40	
Subtract the Arch	—	Æ f 10.00	
		N f 32.40	
Remain. the Leg	{	N g 22.40	
		N h 12.40	
		N i 2.40	

As Radius, is to the Sine of the Vertical Arch;

So is the Tangent Complement of the Angle of Position (at the Place in the Equator,) to the Tangent of the Arch's Latitude. Or thus;

As Radius .. S. Nf, Ng, &c. :: T. Angle aNf .. T. Leg af, bg, &c.			
As S. 90d. .. S. 32d. 40m. :: T. 60d. 22m. .. T. 43.30			
22 40	—	34.07	} Lat. of { a b c d
12 40	—	21.05	
2 40	—	4.41	

I have calculated the Latitude of the Arch for every 10 Degrees Difference of Longitude, but by the same Method the Practitioner may do it for each 5 Degrees, and then it will be more exact.

The Course and Distance from each of these Places are found (by Chapter 4. Section 3. Problem 2. of *Mercator's Sailing*, in pages 93 and 94) in like manner as in the third Step of the last Problem, and is as followeth.

For the Courses, the Proportion is,

As Mer. Dif. Lat. .. Dif. Long. :: Rad. .. T. of the Course requir.			
As 570 Min. .. 600 Min. :: T. 45d. .. T. 46d. 28m. SW. from Z to a			
725	—	39.37	} SW. { a to b b to c c to d d to N
884	—	34.10	
1014	—	30.28	
As 281 Min. .. 160 Min. :: T. 45d. .. T. 29.39			
	N 4		For

2. For the Distances, the Proportion is,

As S. c. Course .. Diff. Lat. : : Radius .. Distance required.

AsS. 43d. 32m .. 390 Min. :: S. 90d. .. 565 Min. from Z to a

50d. 23m. .. 563	_____	731	} from {	a to b
55d. 50m. .. 782	_____	945		b to c
59d. 32m. .. 984	_____	1141		c to d
60d. 21m. .. 281	_____	323		d to N

55d. 50m. .. 782 ——— 945 (from) b to c

59d, 32m. .. 984 ————— 1141 { from } c to d

60d. 21m. .. 281 ————— 323) (d to N

This may serve for a sufficient Explanation of this Problem, the whole is in the Table following.

Places	Places Latitudes.	Meri- dional Parts	Mer- Diff. Lat.	Difference of Longi- tude.	Diff. of Latit.	Courses from Place to Place.	Distances of Places.
	D.M.	Min.	Min.	D. M.	D M.	D. M.	Minutes
Z	50.00	3474	570	10 or 600	6.30	S 46 28 W	565
a	43.30	2004	725	10 or 600	9.23	S 39 37 W	731
b	34.07	2179	884	10 or 600	13.02	S 34 10 W	945
c	21.35	1295	1014	10 or 600	16.24	S 30 28 W	1142
d	04.41	281	281	2.40 or 160	4.41	S 29 29 W	223
N	00.00	0					

The whole Distance is — 3706

Case 3. The second kind ; *Both Places in North Latitude, or both in South Latitude, as for Example:*

Problem 3. Suppose the Lizard and Island Barbadoes : I demand the Angles of Position ; the Great Circle's Distance between them ? The Latitude of the Arch at every 10 Degrees Difference of Longitude ? With the Course, and Distance from each of them, according to Mercator ?

The Latitude, and Longitude of these Places, supposed as follows :

Lizard
I. Barbadoes } Latit. { 50.00 } Longit. { 5.24 W.
 } { 13.00 } { 58.04 W.

I. Barbadoes } Latit. { 13.00 } Longit. { 58.04 W.

Their Difference of Longitude is — 52.40 W.

This

This Problem is delineated Stereographically, by the Directions in Problem 7 of Geography, in pages 186 and 187.

In the Oblique Spheric Triangle PZL, *Plate 6. Fig. 2.*

1. Z represents the *Lizard*, in Latitude 50 degrees North.
2. L the Island *Barbadoes*, in Latitude 13 degrees North.
3. The Side PZ the Complement of the Latitude of the *Lizard*, 40 degrees.
4. The Side PL, the Complement of the Latitude of *Barbadoes*, 77 degrees.
5. The Angle ZPL their Difference of Longitude, 52 degrees 40m.

6. PZL } the Angle of Position at { the *Lizard*.

7. PLZ } { Island *Barbadoes*.

8. The Side ZL, the great Circles Distance between them.

For the Angle PZL and PLZ, (by Chapter 5. Section 5. Problem 9. Case 7. of Spheric Trigonometry Oblique, in Pages 144 and 145.) the Proportions are these;

As the Sine of half the Sum of the Complements of both Latitudes, is to the Sine of half their Difference;

So is the Tangent Complement of half their Difference of Longitude, to the Tangent of half the Difference of the Angles of Position. Again,

As the Sine Complement of half the Sum of the Complements of both Latitudes, is to the Sine Complement of half their Difference;

So is the Tangent Complement of half their Difference of Longitude, to the Tangent of half the Sum of the Angles of Position. But shorter thus,

As S. $\frac{1}{2}$ Sum sides .. S. $\frac{1}{2}$ their diff. :: T.c. $\frac{1}{2}$ ZPL .. T. $\frac{1}{2}$ diff. of Angles
As S. 58d. 30m. .. S. 18d. 30m. :: T. 63d. 40m. .. T. 37d. 02m.

Again,

As S.c. $\frac{1}{2}$ Sum sides .. S. $\frac{1}{2}$ their Diff. :: T.c. $\frac{1}{2}$ ZPL .. $\frac{1}{2}$ Sum Ang.

As S. 31d. 30m. .. S. 71d. 30m. :: T. 63d. 40m. .. T. 74d. 48m.

To which the half Diff. above being added 37d. 02m.

The Sum is the Angle of Position at Z 111d. 50m.

And subtracted is the Angle of Position at L 37d. 40m.

For the Side ZL, the Distance, it's found by Chapter 7. Section 2. Case 3. Problem 7. of Geography, in Pages 187 and 188.) to be 56d. 23m. or 3383 Minutes, which is their Distance in the Arch of a great Circle.

To find the Latitudes by which the Arch shall pass, at every 10 deg. Difference of Longitude, from Z representing the *Lizard*

Lizard, describe the Problem Gnomically, and then all the parts of it will be right Lines, which is thus done.

The Problem Gnomically delineated.

1. Make the Angle LPZ equal to 52d. 40m. the Difference of Longitude.

2. Make the Side PZ equal to the Tangent of 40 Degrees, the Complement of the *Lizard's* Latitude.

3. And PL equal to the Tangent of 77 Degrees, the Complement of *Barbadoes* Latitude.

4. Draw the Line LZ, which is the Great Circle's Distance between them, and continue it beyond Z.

5. From P let fall the Perpendicular PB, to cut LZ in B; which being measured on the Scale of Tangents, is 36d. 38m. the Complement of the Arch's greatest Latitude.

6. Then draw Lines from P, each 10 Degrees distant from Z; as Pa, Pc, Pd, Pe, and Pf, which are Meridians, each 10 Deg. of Longitude from the *Lizard*, and from each other.

7. Measure Pa, Pc, &c. on the Scale of Tangents, and it sheweth the Complements of the Latitudes of the Arch, at the respective Places, a, c, d, &c.

These are found by Calculation after this manner:

First. In the Rectangle Spheric Triangle PBZ; there is given the $\left\{ \begin{array}{l} \text{Hypot. PZ 40d. 00m.} \\ \text{Angle PZB 68d. 10m.} \end{array} \right\}$ to find the $\left\{ \begin{array}{l} \text{Leg BP} \\ \text{Angle BPZ.} \end{array} \right.$

Which, by Chapter 5 Section 4. Problem 2. Cases 4 and 6. of *Spheric Trigonometry Rectangular*, in pages 136 and 137, it's thus,

1. For the Leg PB, the Complement of the Arch's greatest Latitude, it's thus;

As the Radius is to the Sine Complement of the greatest given Latitude;

So is the Sine of the Angle of Position (at that Place,) to the Sine Complement of the Arch's greatest Latitude. That is,

As Radius .. Hypot. PZ :: S. Angle PZB .. S. Leg PB.

As S. 90d. .. S. 40d. 00m. :: S. 68d. 10m. .. S. 36d. 38m. which being subtracted from 90d. 00m.

Rems the Arch's greatest Latitude 53d. 22m.

2. For the Vertical Angle PBZ, it's thus;

As Radius, is to the Sine of the greatest given Latitude;

So is the Tangent of the Angle of Position (at that Place,) to the Tangent of the Complement of the Vertical Angle. That is,

As

As Radius .. S.c. Hyp. PZ :: T. Angle PZB .. T.c. Angle BPZ.
 As S. 90d. .. S. 50d. 00m. :: T. 68d. 10m. .. T. 62d. 23m. which
 being subtracted from _____ 90d. 00m.
 Remts the Vertical Angle BPZ _____ 27d. 37m.

Secondly, to find the several Latitudes of the Arch at a, c, d, &c. you may consider, that the several prick'd Lines Pa, Pc, &c. are so many Hypotenuses, to as many several Rectangle Spheric Triangles which have one common Leg PB, the Complement of the Arch's greatest Latitude.

In each of them, there is given a Leg, and it's adjacent Angle, to find the Hypotenuse: that is, in the Triangle PBa, there is given the Leg PB, and Angle BPa, to find the Hypotenuse, Pa; and so in all the rest.

And the several Vertical Angles BP a, BP c, BP d, &c. are found by a continual Addition of 10 Degrees, to the Angle BPZ, 27d. 37m. till the Sum exceed not 80d. 17m. the Difference of Longitude given, added to the foresaid 27d. 37m. That is;

To the Angle BPZ 27.37
 Add the Angle Z Pa 10.00

Sum is the Ang. $\left\{ \begin{array}{l} \text{BP a } 37.37 \\ \text{BP c } 47.37 \\ \text{BP d } 57.37 \\ \text{BP e } 67.37 \\ \text{BP f } 77.37 \end{array} \right.$

These Vertical Angles being thus found, the several Latitudes of the Arch at a, c, d, e, and f, are found by Chapter 5. Section 4. Problem 3. Case 9. of Spheric Trigonometry Rectangular, in Pages 137, and 138, the

Proportion being the same as before, in Case 2. Problem 1. of this Chapter, in Pages 190, and 193, and is as followeth.

As Radius, is to the Sine Complement of the Verticle Angle; So is the Tangent of the Arch's greatest Latitude, to the Tangent of the Arch's Latitude required. Or thus;

As Rad. .. S.C. BP a, BP c, &c. :: T.c. Leg BP .. T.c. Pa, Pc, &c.
 As S. 90d. .. S. 52d. 23m. :: T. 53d. 22m. .. T. 46.49

42d. 23m	_____	42.11	$\left\{ \begin{array}{l} \text{Lat. of } a \\ \text{c} \\ \text{d} \\ \text{e} \\ \text{f} \end{array} \right.$
32d. 23m	_____	35.46	
22d. 23m	_____	27.07	
12d. 23m	_____	16.05	

Which Latitudes, place in the Table following.

Thirdly,

Places	Places Latitudes.	Meri- dional Parts.	Mer. Diff. Latit.	Difference of Lon- gitude.	Diff. of Lat.	Courses from Place to Place.	Distan- ces of Places.
	d. m.	Min.	Min.	d. m.	d. m.	d. m.	Min.
Z	50.00	3474	287	10 or 600	3.11	S 64 22 W	441
a	46.49	3187	391	10 or 600	4.38	S 56.5 W	509
c	42.11	2796	495	10 or 600	6.25	S 50 30 W	605
d	35.46	2301	610	10 or 600	8.39	S 44 30 W	728
e	27.07	1691	713	10 or 600	11.02	S 40.05 W	865
f	16.05	978	191	2° 46' or 160	3.05	S 38.10 W	235
L	13.00	787					
The whole Distance							3383

Thirdly, The Course and Distance in the two Columns of this Table, are found by Chapter 4. Section 3. Problem 2. of *Mercator's Sailing*, in Pages 93 and 94, in the same manner as in the two last Problems in this Chapter; thus,

1. For the Courses, the Proportion is,

As Mer. Diff. Lat. :: Diff. Long. :: Radius :: T. of the Course reqd.

As 287 Min. :: 600 Min. :: T. 45d. :: T. 64d 22m SW. from Z to a

391	56d 55m	} S.W. from {	a to c c to d d to e e to f f to L
495	50d 30m		
610	44d 30m		
713	40d 05m		

As 191 Min. :: 160 Min. :: T. 45d. :: T. 38d 08m

2. For the Distances, the Proportion is,

As S.c. Course :: Diff. Lat. :: Radius :: Distance required.

As S. 25d. 38m. :: 191 Min. :: S. 90d. :: 441 Min. from Z to a

33d 05m	278	509	} from {	a to c c to d d to e e to f f to L
39d 30m	385	605		
45d 30m	519	728		
49d 55m	662	865		
51d 50m	185	235		

Thus is this third Problem sufficiently explained in every Part of it.

Case 3. The Third Kind; One Place in North Latitude, and the other in South Latitude, as for Example.

Problem 4. Suppose Cape Cod in New-England, and Cape Bona Esperance: I demand the Angles of Position? The Great Circles Distance between them? The Latitude of the Arch at every

every 10 Degrees Difference of Longitude ? the Course and Distance of each according to Mercator ?

The Latitude and Longitude of these Places, supposed to be as follows ;

	d. m.		d. m.
Cape Cod		Lat. { 42 10 N. }	Longit. { 67 45 W.
Cape Bona Esper.		{ 34 25 S. }	{ 17 10 E.

Their Difference of Longitude 84 55 E.

In the Oblique Spheric Triangle PZD, Plate 6. Fig. 3.

1. Z represents Cape Cod, in Latitude 42d. 10m. North.

2. D Cape Bona Esperance, in Latitude 34d. 25m. South.

3. The Side PZ the Complement of the Latitude of C. Cod, 47d. 50m.

4. The Side PD, the Distance of Cape Bona Esperance, from the North Pole, which is its Latitude added to 90 Degrees equal to 124d. 25m.

5. The Angle ZPD their Difference of Longitude, 84d. 55m.

6. PZD } the Angle of Position at Cape { Cod

7. PDZ } { Bona Esperance

8. The Side ZD the Great Circle's Distance between them.

For the Angles PZD and PDZ, (by Chapter 5. Section 5.

Problem 9. Case 7. in Pages 144 and 145, the Proportions are,

	d. m.		d. m.
Side { PD 124 25		The Angle DPZ	84 55
{ PZ 47 50			
The Sum	172 15	The half Sum	86 07
The Diff.	76 35	The half Diff.	38 17
As S. $\frac{1}{2}$ Sum sides .. S. $\frac{1}{2}$ their Diff. :: T.c. ZPD .. T. Diff Aug. req.		Which sub. from 90 00	
As S. 86d. 07m. .. S. 38d. 17m. :: T. 47d. 33m. .. T. 34d. 10m.		Its Complement	47 33
As S. 03d. 53m. .. S. 51d. 43m. -			85d. 39m.

Added, giveth the greater Angle PZD 119d. 39m.

Subtracted is the less Angle PZD 51d. 19m.

The Distance ZD is found (by Chapter 5. Section 3. Case 3. Problem 8. of Geography) in pages 188 and 189, to be 108d. 59m. or 6539 Minutes.

To find the Latitude by which the Arch shall pass at each 10 Degrees Difference of Longitude from Z, representing Cape Cod ; describe the Problem Stereographically on the Plane of the Equator, and then all the Meridians will be Right Circles.

To delineate the Problem Stereographically, Plate 6. Fig. 3.

1. De-

1. Describe the Primitive Circle, and make the Angle DPZ equal to 84d. 55m. the Difference of Longitude (by Chapter 5. Section 1. Problem 2. Case 1. in Page 112. of *Spheric Geometry*,) by drawing two Right Circles.

2. Make the Side PZ equal to the Half-Tangent of 47d. 50m. the Complement of the Latitude of Cape Cod.

3. And PD equal to the Half-Tangent of 124d. 25m. (the Latitude of Cape Bona Esperance added to 90d.) by Chap. 5. Sect. 1. Prob. 6. Case 2. of *Spheric Geometry*, in Pages 116. and 117.

4. Then by Chapter 5. Section 1. Problem 4. of *Spheric Geometry* (in Pages 113 and 114) through Z and D draw a Great Circle.

5. From P (by Problem 5. of *Spheric Geometry*, in Page 114) let fall the Perpendicular PB, to cut ZD in B; which being measured on the Scale of Half-Tangents, is 40d. 06m. the Complement of the Arch's greatest Latitude.

6. Then draw Lines from P, each 10d. distant from Z; as Pa, Pc, Pd, Pe, &c. which are Meridians, each 10d. of Longitude from one another, and from the Meridian of Cape Cod.

7. Measure Pa, Pc, &c. on the Scale of Half-Tangents, and it sheweth the Complement of the Latitudes of the Arch at the respective Places, a, c, d, &c.

These are found by Calculation after this manner, which is in all respects like the Work of the last Problem.

First, In the Rectangle Spheric Triangle PBZ.

1. For the Leg BP, the Complement of the Arch's greatest Latitude, it's thus;

As Radius .. S. Hypot. PZ :: S. Angle PZB .. S. Leg PB.

As S. 90d. .. S. 47d. 50m. :: S. 60d. 21m. .. S. 40d. 06m.

Which subtract from _____ 90d. 00m.

Rests the Arch's greatest Latitude _____ 49d. 54m.

2. For the Vertical Angle PZB, it's thus;

As Radius .. S.c. Hypot. PZ :: T. Angle PZB .. T.c. Angle BPZ

As S. 90d. .. S. 42d. 10m. :: T. 60d. 21m. .. T. 49d. 42m.

Which subtracted from _____ 90d. 00m.

Rests the Vertical Angle BPZ _____ 40d. 18m.

Secondly, For the several Latitudes at a, c, d, &c. add 10d. to the Angle BPZ (in Continuation) Eight times, which produceth the several Vertical Angles, BPa, BPC, BPD, &c.

†

To

	d. m.
To the Angle BPZ —	40.18
Add the Angle ZPa —	10.00
Sum, is the Angle	BPa 50.18
	BPc 60.18
	BPd 70.18
	BPe 80.18
	BPf 90.18
	BPg 100.18
	BPh 110.18
	BPi 120.18

These Vertical Angles being thus found, the several Latitudes of the Arch, at a, c, d, e, f, g, h, and i, are found by Chapter 5. Section 4. Problem 3. Case 9. of Spheric Trigonometry Rectangular; the Proportions being the same as before in Case 2. Problem 1. of this Chapter, in pages 193, and 194, as follows.

As the Radius, to the Sine Complement of the Vertical Angle :

So is the Tangent of the Arch's greatest Latitude, to the Tangent of the Arch's Latitude required. Or thus,

As Radius .. S.c. BPa, BPc, &c. :: T.c. Leg BP .. T.c. Pa, Pc, Pd, &c.

As S. 90d. .. S. 39d.42m. :: T. 49d. 54m. .. T. 37.11	d. m.	Latitude of	a c d e f g h i
29d.42m. —————	30.26		
19d.42m. —————	21.49		
09d.42m. —————	11.19		
00d.18m. —————	00.21		
10d.18m. —————	11.59		
20d.18m. —————	22.23		
30d.18m. —————	30.56		

Thirdly For the Courses, and Distances, they are found by Chapter 4. Section 3. Problem 2. of *Mercator's Sailing*, in pages 93, and 94, as follows,

For the Courses, the Proportion is,

Mer. Diff. Lat. .. Diff. Long. :: Radius .. T. Course.

As 389 Min. .. 600 Min. :: T. 45d. .. T. 57d.03m SE. from Z to a.		S. E. from	a to c c to d d to e e to f f to g g to h h to i i to D
485 —————	51d.03m		
578 —————	46d.04m		
660 —————	42d.16m		
704 —————	40d.26m		
702 —————	40d.31m		
655 —————	42d.30m		
574 —————	46d.16m		
As 249 Min. .. 295 Min. :: T. 45d. .. T. 49d.50m			

For

2. For the Distances, the Proportion is,

As S. c. Course .. Diff. Lat. : : Radius .. Distance required.

As S. 32d. 57m .. 299 min. : : S. 90d. .. 550 Min. from Z to a.

38d 57m .. 403	641	from	a to c
43d 56m .. 519	748		c to d
47d 44m .. 630	851		d to e
49d 34m .. 700	920		e to f
49d 29m .. 698	918		f to g
47d 30m .. 624	847		g to h
43d 44m .. 513	742		h to i
40d 10m .. 209	324		i to D

Which place orderly, as in the Table following, and it's finish'd.

Places	Places Latitude.	Meri- dian Part	Mer Diff. Lat.	Difference of Longitude.	Difference of Latitude.	Courses from Place to Place.	Diff. of Places
	d. m.	Min.	Min.	d. m.	d. m.	d. m.	Min.
Z	42.10N	2795	389	10 or 600	4.59 or 299	S 57.03 E	550
a	37.11	2406	486	10 or 600	6.41 or 403	S 51.03 E	641
c	30.28	1920	577	10 or 600	8.39 or 519	S 46.04 E	74
d	21.49	1343	660	10 or 600	10.30 or 630	S 42.16 E	851
e	11.19N	683	74	10 or 600	11.40 or 700	S 40.26 E	920
f	00.21 S	21	703	10 or 600	11.38 or 698	S 40.31 E	918
g	11.59	724	655	10 or 600	10.24 or 624	S 42.30 E	847
h	22.23	1379	574	10 or 600	8.33 or 513	S 46.16 E	742
i	30.56	1953	249	4.55 or 295	3.29 or 209	S 49.50 E	324
D	34.25 S	2202					

The whole Distance is ——— 6541

Note ; The Arch of a great Circle may be described on a *Mercator's Chart*, and thereby much of the Calculative Work may be spared ; for having the several Latitudes of the Arch at every 5, or 10 Degrees Difference of Longitude, (by Chap. 4. Section 1. Problem 1 and 2, of the *Use of Mercator's Chart* in pages 84 and 85, those places may be prick'd down in the Chart, and then with a Black Lead Pencil draw Lines from place to place, which will represent the Great Circle, and by Problem 3 and 4, of the *Uses of that Chart*, in Page 85, the

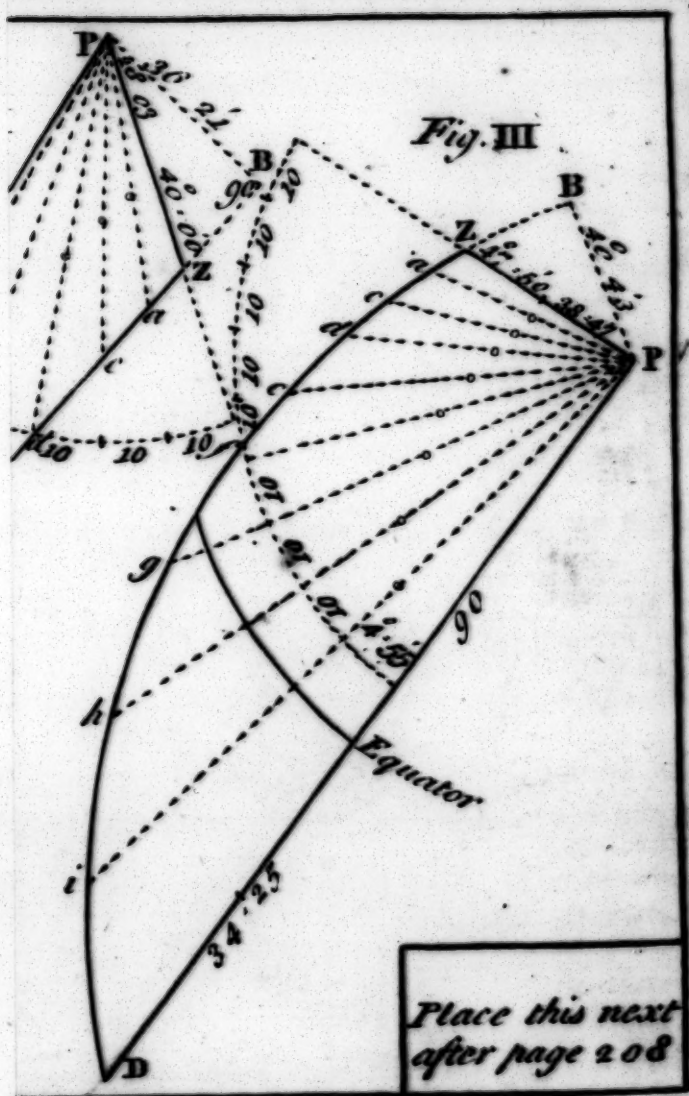
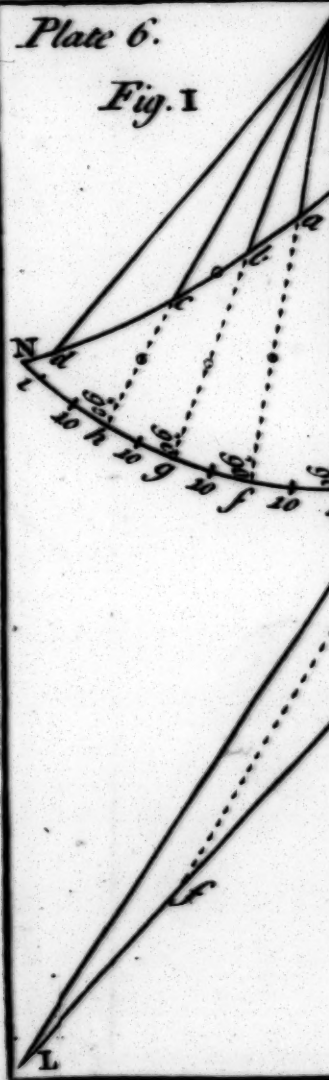
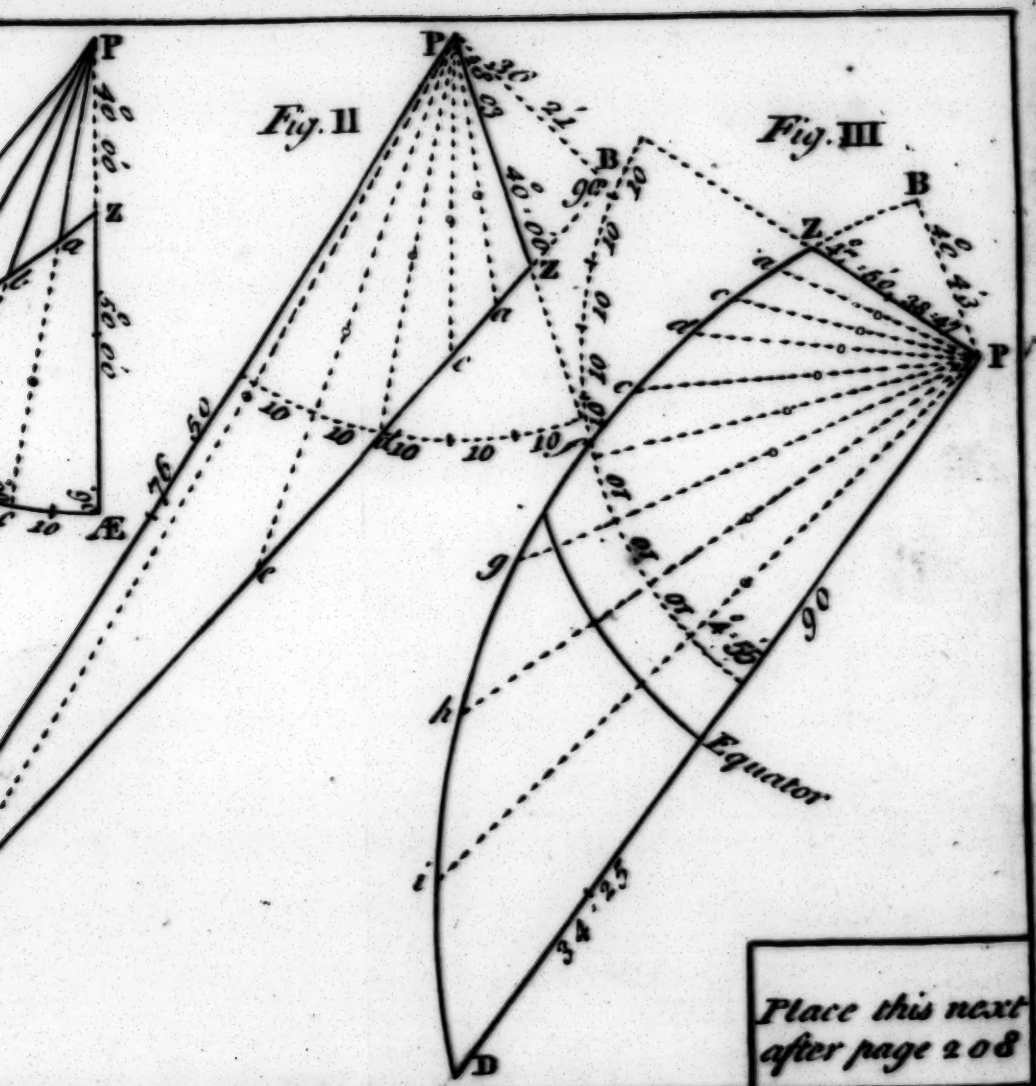
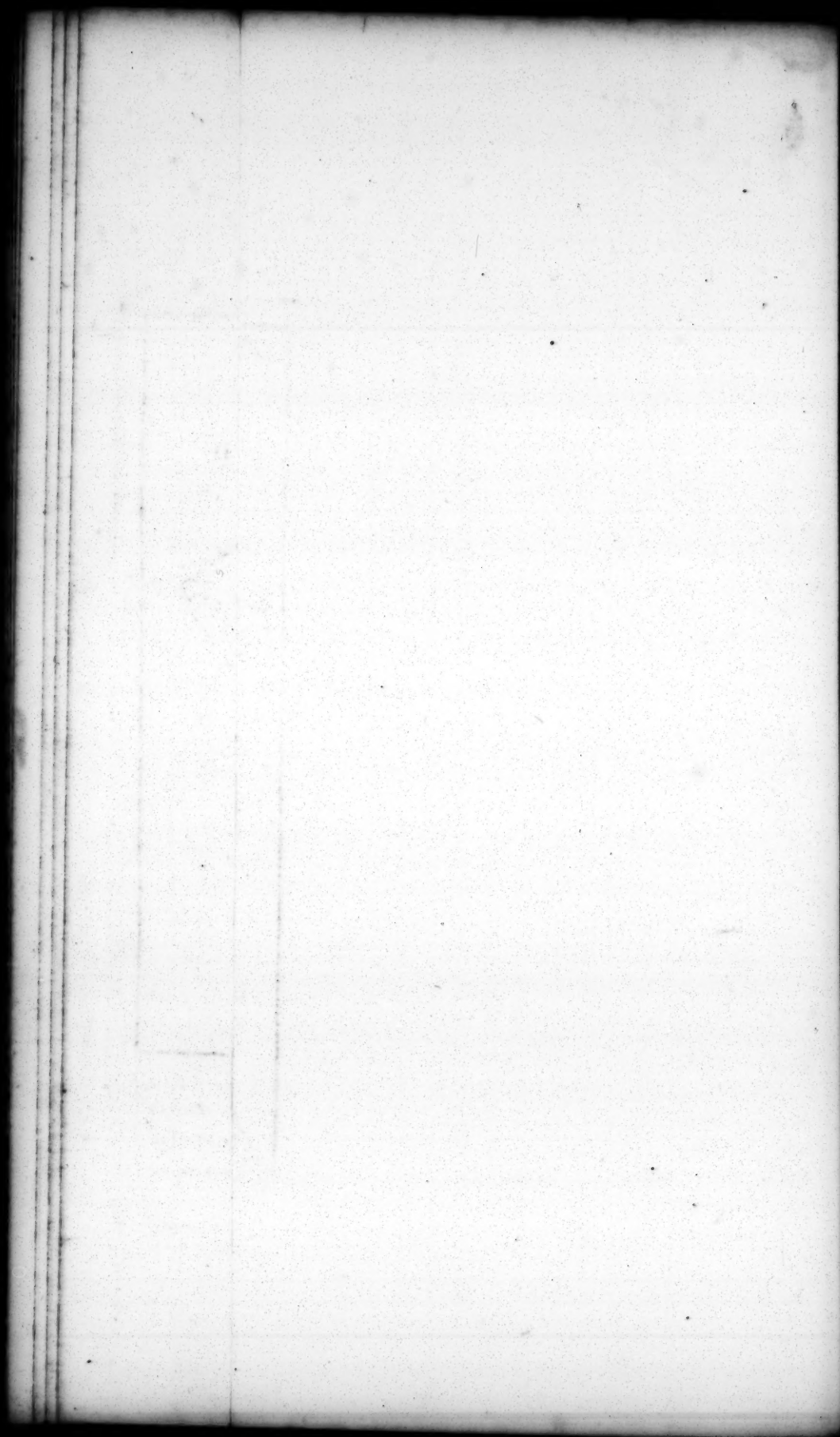


Plate 6.

Fig. I







the Courses, and Distances from each other may be found, and at any Time those Lines may be wiped out, and the Chart fit to serve at any other Time, or for any other Place.

So that any Problem, being thus drawn, in a *Mercator's Chart*, the nearer the Ship sails to it, the nearer to a *Great Circle* she makes her Way good, and consequently the shorter her Passage; this being the only Thing *Great-Circle Sailing* is useful for, of which I have said enough to explain it.

Thus is finished the *Third Part of Navigation*, or the *Third Kind of Sailing*, and now we pass on to *Astronomy*.

CHAPTER IX.

Spheric Trigonometry *applied in sundry Astronomic Problems, useful in the Art of Navigation.*

WHAT a *Sphere* or *Globe* is, and the Circles generally drawn on it hath been taught (Chapter 6, Section 2, and 3) in the Description of both Globes: But how these are drawn on a Plane, and form divers Triangles, (from whence Multitudes of useful and pleasant Problems may be framed,) is our present Work.

Section I. *Astronomic Definitions.*

THE Circles drawn upon the Sphere's Surface, are either Great, or Less Circles.

I. *The Great Circles, and their Poles described.*

Great Circles, are those which divide the Globe, or Sphere into two equal Parts, and are principally these Six; the Equinoctial, Ecliptic, Meridian, Horizon, Azimuth, and Circle of Longitude.

1. The *Equinoctial*, is a Great Circle which lies in the Middle, between the two Poles of the World, and consequently each Pole is 90 degrees distant from it, cutting all Meridians at Right Angles, and divides the World into the Northern and Southern Hemispheres, as the Right Circle *ÆAQ*. in Plate 7. Fig. 1. and 2.

The Poles of the World are two fixed Points in the Havens, diametrically opposite to each other, the one in the Northern Hemisphere, called the (Artic or) North Pole, the other in the Southern Hemisphere, called the (Antartic or) South Pole, as P and I. Plate 7. Fig. 1. and 2.

The Axis of the World, is an imaginary Line drawn from Pole to Pole, about which the Diurnal Motion (as supposed) from East to West, is performed; as *PAI*.

O

2. The

2. The *Ecliptic* (is a great Circle) crossing the Equinoctial in (two opposite Points) the Beginning of *Aries* and *Libra*, making an Angle (called its Obliquity) of 23d. 30m. as the Right Circle, $\ominus$ A $\wp$. Plate 7. Figure 1.

This Circle is divided into Twelve equal Parts called Signs, each containing 30 deg. whose Names and Characters follow.

<i>Aries</i> γ	} called Northern Signs.	<i>Libra</i> — $\sim$	} called Southern Signs.
<i>Taurus</i> β		<i>Scorpio</i> — $\mathfrak{m}$	
<i>Gemini</i> π		<i>Sagittarius</i> ζ	
<i>Cancer</i> $\omin�$		<i>Capricornus</i> $\wp$	
<i>Leo</i> Ω		<i>Aquarius</i> — $\mathfrak{z}$	
<i>Virgo</i> $\mathfrak{M}$		<i>Pisces</i> — $\mathfrak{X}$	

The *Zodiac*, is a Zone or Girdle, having eight Degrees of Latitude on each Side the Ecliptic; in which Space, the Planets make their Revolutions, being divided and distinguished by the Twelve Signs.

The *Poles of the Ecliptic*, are two opposite Points 23d. 30m. distant from the Poles of the World: as K and L.

3. The *Meridians* are great Circles, passing through both Poles of the World, and crosseth the Equinoctial at Right Angles, as P $\mathfrak{A}$ E I, and P M I, &c. Plate 7. Fig. 1st and 2d.

The *Colures*, are two Meridians dividing the Equinoctial and Ecliptic into four equal Parts; one of these passeth by the Equinoctial Points, *Aries* and *Libra*, and is called the Equinoctial Colure, as P A I. Plate 7. Figure 1.

The other passeth by the Beginning of *Cancer* and *Capricorn*, and is called the *Solstitial Colure*; as P $\omin�$ A E I $\wp$ Q. Plate 7. Figure 1.

The *Sun's Meridian*, is that Meridian which passeth over the Sun's Center.

A *Star's Meridian*, is that Meridian which passeth thro' the Middle of that Star.

4. The *Horizon*, is a great Circle 90 deg. distant from the *Zenith* and *Nadir*, cutting all Azimuths at Right Angles, and dividing the World into two equal Parts, the upper and visible Hemisphere, and the lower and invisible Hemisphere. This Circle is represented by the Right Circle SAB. Plate 7. Figure 2.

The *Zenith* and *Nadir*, are two Points diametrically opposite, and are the Poles of the Horizon: The *Zenith* is the Vertical Point, or Point right over our Heads, as Z. The *Nadir* is directly opposite thereto, as N. Plate 7. Fig. 2.

5. The *Azimuth*, or *Vertical Circles*, are great Circles concurring and intersecting each other in the *Zenith* and *Nadir*, and

and cross the Horizon at Right-angles, as ZCN, and ZAN, &c.

The *Prime Vertical*, is that Azimuth Circle, which passeth through the East and West Points of the Horizon, as the Right Circle ZAN.

The *Meridian of a Place*, is that Meridian which passeth thro' the Poles of the World, and the Zenith and Nadir of the said Place, as ZPBNISÆZ, Plate 7. Figure 2.

6. Circles of *Longitude*, are great Circles intersecting each other in the Poles of the Ecliptic, as KAL, and KVL, Plate 7. Figure 1.

II. The Less Circles defined.

Less or Small Circles, are those which divide the Sphere into two unequal Parts, and are drawn parallel to some great Circle, and therefore are called *Parallel Circles*; and are of three kinds, viz. *Parallels of Declination*, *Parallels of Latitude*, and *Parallels of Altitude*.

1. *Parallels of Declination* are (small Circles) parallel to the Equinoctial, imagined to pass thro' every Degree and Minute of the Meridian, between the Equinoctial and each Pole of the World, as g f g , and v p h i . Plate 7. Figure 2.

The *Tropic's* are two *Parallels of Declination* 23d. 30m. distant from the Equinoctial, limiting the Sun's greatest Declination.

The *North Tropic*, passeth by the beginning of Cancer, and is called the *Tropic of Cancer*; as g f g . Plate 7. Figure the 1st.

The *South Tropic*, passeth by the beginning of Capricorn, and is called the *Tropic of Capricorn*, as v p h i . Plate 7. Figure the 1st.

The *Polar Circles*, are two *Parallels of Declination*, 66d. 30m. distant from the Equinoctial, and 23d. 30m. from each Pole of the World.

That which is adjacent to the North Pole, is called the *Arctic Circle*; as K n o: and the other the *Antartic Circle*; as L p r. Plate 7. Figure the 1st.

2. *Parallels of Latitude*, are (Small Circles) parallel to the Ecliptic, imagined to pass through every Degree and Minute of the Colures, between the Ecliptic and the Poles thereof, as w x y. Plate 7. Figure 1.

3. *Almicantbers*, or *Parallels of Altitude*, are small Circles parallel to the Horizon, imagined to pass through every Degree and Minute of the Meridian, between the Horizon and the Zenith; as a l t. Plate 7. Figure 2.

These Definitions compar'd with Chapter 6. Section 4. (of the Use of the Coelestial Globe, in pages 168, and 169.) and well consider'd, will make way for the understanding the following Problems.

Section II. *Spheric Trigonometry Rectangular, applied in Astronomic Problems, useful in Navigation.*

AND because the Sun's Place in the Ecliptic, is the ground of the succeeding Problems, you have here (out of Mr. *The Street's Memorial Verses on the Ecclesiastic and Civil Kalendar*) a General Rule; which for common Uses may serve, and is as follows.

1. *To know the Day of the Month the Sun entereth any of the Twelve Signs.*

The Rule, Twice 9, twice 10, 4 Twelves, 11;

Then 10, then 9, then 8 or 7:

That is, counting *March* the first Month, the Sun enters

♈ <i>March</i> 9	♌ <i>July</i> — 12	♐ <i>November</i> 11
♉ <i>April</i> 9	♍ <i>August</i> — 12	♑ <i>December</i> 10
♊ <i>May</i> 10	♎ <i>September</i> 12	♒ <i>January</i> 9
♋ <i>June</i> 10	♏ <i>October</i> 12	♓ <i>February</i> 8

2. *To find the Degree of the Sun's Place on any given Day.*

The Rule. From the Day of the Month given, (if you can) subtract the Day of his Entrance into the Sign of that Month, the Remainder is the Degree of the Sun's Place in that Sign. Or else,

When you can't subtract, add 30 to the Day given, and from the Sum subtract the Day of the Entrance into the Sign of that Month, the Remainder shall be the Degree of his Place in the Sign preceding the Month given.

Example 1. *March* 20th, I desire to know the Sun's Place?

From *March* the 20th, the Day given, subtract the Sun's Entrance, ♈ *March* 9.

The Remainder 11 is the Degree of the Sun's Place in ♈.

Example 2. *May* the 4th, I desire to know the Sun's Place?

To the Day given *May* the 4

Add ————— 30

Sum is ————— 34 from which

Subtract the Sun's Entr. into ♊ *May* 10

Remainder is the Sun's Place in ♏ ——— 24 Degrees.

Problem 1. The Sun's Place in the Ecliptic, and his greatest Declination given; to find his Right Ascension, and present Declination.

Definition 1. *Ascension*, is the Rising of the Sun, Star or any part of the Equinoctial above the Horizon; and *Descension* is the Setting thereof.

2. *Right Ascension*, is an Arch of the Equinoctial, intercepted between the beginning of γ , and any Meridian, and counted according to the Order, or Succession of the Signs: Or, it's that Degree and Minute of the Equinoctial (counted as before) which cometh to the Meridian with the Sun, Star, or with any part of the Ecliptic; as A M. Plate 7. Figure 1.

3. *Declination*, is an Arch of a Meridian contained between the Sun, or Star's Center, and the Equinoctial, as M C.

4. The Sun's greatest Declination is an Arch of the Solstitial Colure, contained between the Equinoctial and the Ecliptic, and is equal to 23d. 30m. as $\text{Æ} \text{ } \text{G}$, and $\text{Q} \text{ } \text{V}$. Plate 7. Figure 1.

Example. The Sun in *Taurus*, 24d. 15m. I demand his Right Ascension, and Declination?

In the Rectangle Spheric Triangle AMC. Plate 7. Fig. 1.

1. AMC the Right Angle.
2. AC the Sun's Longitude from the next Equinoctial Point.
3. AM his Right Ascension from the same Point.
4. MAC the Sun's greatest Declination, equal to 23d. 30m.
5. MC his present Declination.

Note; The Sun in $\gamma, \delta, \epsilon, \zeta, \eta, \theta, \iota, \kappa$, the nearest Equinoctial Point is the beginning of γ : But when the Sun is in $\text{G}, \text{D}, \text{R}, \text{A}, \text{M}$, or J , the nearest Equinoctial Point is A .

So that in this Problem, the Sun being in δ 24d. 15m. he is 54d. 15m. from the nearest Equinoctial Point γ .

To project this Problem *Stereographically* on the Plane of the Solstitial Colure,

1. Describe the Primitive Circle with a Chord of 60 Degrees, and quarter it with two Right Circles, ÆA Q (the Equinoctial) and PAI (the Equinoctial Colure) placing A at its Center, which now is the Solstitial Colure.

2. Make (by Problem 2. Case 1. of *Spheric Geometry*, in Page 112) the Angle ÆA G equal to 23d. 30m. (the Sun's greatest Declination) by laying the Chord of it, from Æ to G , and drawing the Right Circle G A V the Ecliptic.

3. The Ecliptic is divided into the 12 Signs, each 30d. from the Scale of Half-Tangents, by Problem 6. Case 2. of *Spheric Geometry* in pages 116 and 117.

4. On the Ecliptic make AC equal to 54d. 15m. (from the Scale of Half-Tangents) by the same Problem 6. Case 2.

5. Then (by Chapter 5. Section 1. Problem 5. Case 3. of Spheric Geometry, in Page 115,) draw from C a great Circle perpendicular to EAQ , as is the Oblique Circle PCMI, to cut EAQ in M, and it's done.

For in the Rectangle Spheric Triangle AMC, the Legs AM, and MC are the two Things required, and may be measured by Chapter 5. Section 1. Problem 7. Cases 2 and 3. of Spheric Geometry in Page 118.

But by Spheric Trigonometry, having the Hypotenuse and one Angle given, the Proportions are as follow.

1. To find the Sun's Right Ascension, by Chapter 5. Section 4. Problem 2. Case 5. of Spheric Trigonometry Rectangular, in Pages 136 and 137, it's thus;

As the Radius, is to the Sine Complement of the Sun's greatest Declination;

So is the Tangent of the Sun's Longitude from the nearest Equinoctial Point, to the Tangent of the Sun's Right Ascension from the said Point. Or thus;

As Radius .. S.c. Angle MAC :: T. Hypot. AC .. T. Leg AM.

As S. 90d. .. S. 66d. 30m. :: T. 54d. 15m. .. T. 51d. 52m.

Note; This Proportion finds the Sun's Right Ascension only when he is in the first Quarter of the Ecliptic; that is, in γ , δ , or π : But when the Sun is in the second Quarter ϵ , ζ , or η , it must be subtracted from 180d. and when he is in $\imath$, κ , or λ , it must be added to 180d. and in the last Quarter ν , ξ , or χ , that found by this Proportion, must be subtracted from 360d. and so will you have the Sun's Right Ascension from γ , (for any Place in the Ecliptic) desired.

2. To find the Sun's present Declination, by Chapter 5. Section 4. Problem 2. Case 4. of Spheric Trigonometry Rectangular, in Page 136, it's thus;

As the Radius, is to the Sine of the Sun's Longitude from the nearest Equinoctial Point;

So is the Sine of the Sun's greatest Declination, to the Sine of the Sun's present Declination. Or thus;

As Radius .. S. Hypot. AC :: S. Angle MAC .. S. Leg. MC.

As S. 90d. .. S. 54d. 15m. :: S. 23d. 30m. .. S. 18d. 51m.

Note; The Sun being in any of the Northern Signs, γ , δ , π , ϵ , ζ , or η , his Declination is North; but when in any of the Southern Signs $\imath$, κ , λ , ν , ξ , or χ , his Declination is South.

In this Rectangle Spheric Triangle AMC (Plate 7. Figures 1.) may the two succeeding Problems be resolved. Prob

Problem 2. The Sun's Right Ascension given; to find his Place in the *Ecliptic*, and his *Declination*?

Example. The Sun's Right Ascension 128d. 9m. where is his Place in the *Ecliptic*, and what is his *Declination*?

Here is one Leg and its adjacent Angle given; to wit, the Leg AM 51d. 51m. the Right Ascension (subtracted from 180d.) and Angle MAC 23d. 30m. the Sun's greatest Declination; which Triangle is made by Problem 12. of *Spheric Trigonometry Geometric*, in page 125. and it's Solution is by Chapter 5. Section 4. Problem 3. Case 7 and 9, of *Spheric Trigonometry Rectangular*, in Pages 137, and 138, thus;

1. For the Sun's Place in the *Ecliptic*, it's thus;

T. Leg AM .. Radius :: S. c. Angle MAC .. T. c. Hypot. AC. or
As Radius .. S. c. Ang. MAC :: T. c. Leg AM .. T. c. Hyp. AC.
As S. 90d. .. S. 66d. 30m. :: T. 38d. 09m. .. T. 35d. 46m.

Which subtract from _____ 90d. 00m.

Resteth the Sun's Longitude _____ 54d. 14m.
wanting of $\simeq$; so that his Place is 5d. 46m. in Ω .

2. For the Sun's present Declination, it's thus,

As T. c. Angle MAC .. Radius :: S. Leg AM .. T. Leg MC, or
As Radius .. S. Leg AM :: T. Angle MAC .. T. Leg MC.
S. 90d. .. S. 51d. 51m. :: T. 23d. 30m. .. T. 18d. 52m. the
Sun's Declination North decreasing.

Problem 3. The Sun's Declination given; to find his Place in the *Ecliptic*, and Right Ascension?

Example. The Sun's Declination 16d. 39m. South increasing: I demand his Place in the *Ecliptic*, and his Right Ascension?

Here is a Leg and its opposite Angle given; that is, the Angle MAC 23d. 30m. the Sun's greatest Declination, and the Leg MC 16d. 39m. his present Declination, which Triangle is made by Prob. 13 of *Spheric Trigonometry Geometric*, in page 126; whose Solution is by Ceap. 5, Sect. 4, Prob. 4, Case 10 and 12. of *Spheric Trigonometry Rectangular*, in pages 138 and 139, thus;

1. To find his Place in the *Ecliptic*, it's thus;

As S. Angle MAC .. Radius :: S. Leg MC .. S. Hypot. AC.
As S. 23d. 30m. .. S. 90d. :: S. 16d. 39m. .. S. 45d. 56m.
the Sun's Longitude beyond $\simeq$, because his Declination is South increasing; so that the Sun's Place is 15d. 56m. in Ω .

2. For his Right Ascension, 'tis thus;

Radius .. T. c. Angle MAC :: T. Leg MC .. S. Leg AM
T. 45d. .. T. 66d. 30m. :: T. 16d. 39m. .. S. 43d. 27m.

To which add _____ 180d. 00m.

The Sum is the Sun's Right Ascension — 223d. 27m. from γ .

Problem 4. *The Latitude of a Place, and the Sun's Declination given; to find the Sun's Amplitude, and Ascensional Difference.*

Definition 1. Latitude of a Place, or Latitude upon the Earth, is an Arch of the Meridian of that Place, contained between the Zenith (of that Place) and the Equinoctial, as $Z\text{Æ}$; equal thereunto is the Height of the Pole above the Horizon, as BP . Plate 7. Figure the 2d

2. *Amplitude*, is an Arch of the Horizon, contained between the Ecliptic and the Equinoctial, and sheweth how far the Sun, or any Star riseth, or setteth from the East, or West Points of the Horizon; as AR . Plate 7. Figure the 2d.

3. *Ascensional Difference*, is the Difference between the Right Ascension, and the Oblique Ascension, or Descension: Or it's an Arch of the Equinoctial contained between the Hour Circle of fix a Clock, and that Meridian which passeth by the *Sun* or *Star's* Center, or any Point of the Ecliptic, in their Rising, or in their Setting.

4. *Oblique* $\left\{ \begin{array}{l} \text{Ascension,} \\ \text{Descension,} \end{array} \right\}$ is an Arch of the Equinoctial. contained between the beginning of γ , and that part of the Equinoctial that $\left\{ \begin{array}{l} \text{Riseth} \\ \text{Setteth} \end{array} \right\}$ with the Center of the *Sun* or *Star*, or with any point, part, or portion of the *Ecliptic*, in an *Oblique Sphere*.

d. m.

Example.

Latitude $51^{\circ} 32'$ } *North given; What is his* $\left\{ \begin{array}{l} \text{Amplitude,} \\ \text{Ascens. Differ.} \end{array} \right.$
 Sun's Dec. $23^{\circ} 30'$ }

In the Rectangle Spheric Triangle PBR . Plate 7. Fig. 2.

1. PBR the Rectangle.

2. PB the Latitude, or Height of the Pole above the Horizon.

3. PR the Complement of the *Sun's* Declination.

4. BR the Complement of the *Sun's* Amplitude.

5. BER the Complement of the *Sun's* Ascensional Difference.

To project it stereographically on the Plane of the Meridian.

1 The Primitive Circle being described and quartered (as formerly) with two Right Circles SAB the Horizon, and (ZAN) the Prime Verticle; with A at its Center. Plate 7. Figure the 2d.

2. On the *Primitive Circle*, lay the Latitude 51° d. 32° m. from B to P , and from Z to Æ , (by Problem 6. Case 1. of *Spheric Geometry*, in page 116) and draw the two Right Circles PAI for the Axis of the World, or Hour Circle of Six, and ÆAQ the Equinoctial

3. Then

3. Then (by Problem 9. Case 2. of *Spheric Geometry*, in page 121) draw $\odot$ I f R g parallel to $\overline{EAQ}$, at 23d. 30m. (the given Declination) from it, to cut the Horizon SAB in R, the Place of the *Sun's* Rising and Setting.

4. Through P, R, and I, draw an Oblique Circle, and it's done: For in the Rectangle Spheric Triangle PBR, the Leg BR, and Angle BPR are the two Things required, and may be measured by Problems 7 and 8, of *Spheric Geometry*, in pages 117, 118, and 119.

But by Trigonometry, having the Hypotenuse PR 66d. 30m. and Leg BP 51d. 32m. given, the Proportions by Chap. 5. Section 4. Problem 1. Case 1, and 3. of *Spheric Trigonometry Rectangular*, in pages 135 and 136, are thus:

1. To find the *Sun's* Amplitude, the Proportion is,

As the Sine Complement of the Latitude, is to the Radius;
So is the Sine of the *Sun's* Declination, to the Sine of the *Sun's* Amplitude. Or thus;

As S. c. Leg BP .. Radius :: S. c. Hyp. PR .. S. c. Leg BR.

As S. 38d. 28m. .. S. 90d. :: S. 23d. 30m. .. S. 39d. 52m.

Note, The Amplitude and Declination are ever of one Name; that is, both North, or both South.

2. To find the Ascensional Difference, the Proportion is;
As the Radius is to the Tangent of the Latitude;

So is the Tangent of the *Sun's* Declination, to the Sine of the *Sun's* Ascensional Difference. Or thus;

As Radius .. T. Leg BP :: T. c. Hyp. PR .. S. c. Angle BPR.

As T. 45d. .. T. 51d. 32m. :: T. 23d. 30m. .. S. 33d. 11m. the *Sun's* Ascensional Difference.

Problem 5. *The Latitude of a Place, and the Sun's Declination given; to find his Oblique Ascension, or Descension..*

The Rule. 1. Find the *Sun's* Right Ascension by Problem 3. and the Ascensional Difference by Problem 4. Then,

2. When the Latitude and Declination are both North, or both South, the Ascensional Difference added to, and subtracted from the *Sun's* Right Ascension, the first is the Oblique Descension, the latter is the Oblique Ascension.

3. When the Latitude and Declination are one North, and the other South, add, and subtract as before; the first is the Oblique Ascension, and the latter is the Oblique Descension.

Note; When you cannot subtract, add 360 Degrees to the Right Ascension, and then subtract; also when you have added, if the Sum exceeds 360 Degrees, subtract 360 Degrees therefrom, the Remainder is the Thing required.

Example

Example. Latit. 51d. 32m. North ——— } given; what is
 Sun's Declin. 15d. 40m. South decreasing }
 his Oblique Ascension, and Descension?

1. For the *Sun's Right Ascension*, it's thus;

As Radius .. T. c. Angle MAC :: T. Leg MC .. S. Leg AM.

As T. 45d. .. T. 66d. 30m. :: T. 15d. 40m. .. S. 40d. 04m.

Which subtracted from ——— — 360d 00m.

Remainder is the Sun's Right Ascension — 319d. 56 from γ

2. For his *Ascensional Difference*, it's thus;

As Radius .. T. Latitude :: T. $\odot$ Declin. .. S. $\odot$ Ascen. Dif.

As T. 45d. .. T. 51d. 32m. :: T. 15d. 40m. .. S. 20d. 41m.

Right Ascension found above ——— 319d. 56 from γ .

Added is the $\odot$'s Oblique Ascension — 340d. 37m.

Subtracted is the $\odot$'s Oblique Descension — 299d. 15m.

Problem 6. *The Latitude, and the Sun's Declination given; to find the Time of the Sun's Rising and Setting, and the Length of the Day and Night?*

The Rule 1. Find the Sun's Ascensional Difference by Problem 4, in pages 216 and 217, which is reduced into Time by allowing as hereunder.

15d. 00m. }
 1d. 00m. } for { 1.— Hour — } of Time;
 0d. 15m. } { 0.04 Minutes }
 { 0.01 Minute }

1. The Sun's Ascensional Difference (being reduced into Hours and Minutes) added to, and subtracted from 6 Hours, the one is *Sun-rising*, and the other is *Sun-setting*.

Note. When the Latitude, and Declination are both North, or both South; the Sun riseth before, and sets after Six. But if one be North, and the other South; he then riseth after, and sets before Six of the Clock.

3. Double the Time of Sun-Setting, gives the Length of the Day; also double the Time of Sun-Rising, gives the Length of the Night.

Example. Latitude 51d. 32m. North, Sun's Declination 23d. 30m. North, given; the Sun's *Ascensional Difference*, by Problem 4. is 33d. 11m. equal in Time to 2 Hours 13 Minutes. Therefore the Work is as follows.

d. m. 6 Hours.

Ascen. Diff. 33. 11. Or 2. 13 h. m.

Add, is Sun-Setting — 8. 13 Length of the Day is 16.26

Subtract, is Sun-Rising — 3. 47 Length of the Night is 7.34

In

In the same Rectangle Spheric Triangle PBR (Plate 7. Fig. 2.) may the five next following Problems be resolved; which are for the Learner's Exercise.

Problem 7. Latitude of a Place, and the Sun's Ascensional Difference given; to find his Declination, and Amplitude?

Example. The $\begin{cases} \text{Latitude} \text{ --- } 41^{\circ} 47' \text{ South.} \\ \text{Sun riseth at --- } 7^{\circ} 30' \end{cases}$

Here is a Leg, and its adjacent angle given: that is, the Leg BP $41^{\circ} 47'$ the Latitude, and the Angle BPR $4^{\circ} 30'$ or $67^{\circ} 30'$ the Complement of the Sun's Ascensional Difference; which Triangle is made by Prob 12. of Spheric Trigonometry Geometric, in page 125. and for its Solution, see Chapter 5. Section 4. Problem 3. Cases 8 and 9, of Spheric Trigonometry Rectangular, in pages 137 and 138, is thus;

1. For the Sun's Declination, it's thus;

As Radius $\cdot$ S $\odot$ Asc. Diff. $::$ T.c. Latitude $\cdot$ T. $\odot$ Declin.

As S. 90° $\cdot$ S. $22^{\circ} 30'$ $::$ T. $48^{\circ} 13'$ $\cdot$ T. $23^{\circ} 11'$ N.

2. For the Sun's Amplitude, it's thus:

As T. $\odot$ Asc. Diff. $\cdot$ Radius $::$ S. Latitude $\cdot$ T.c. $\odot$ Ampli. Or

As S. Latitude $\cdot$ Radius $::$ T. $\odot$ Asc. Diff. $\cdot$ T. $\odot$ Ampli.

As S. $41^{\circ} 47'$ $\cdot$ S. 90° $::$ T. $22^{\circ} 30'$ $\cdot$ T. $31^{\circ} 52'$ N.

Problem 8. Latitude, and Sun's Amplitude given; to find his Declination, and Ascensional Difference.

Example. The $\begin{cases} \text{Latitude} \text{ --- } 36^{\circ} 17' \text{ North.} \\ \text{Sun's Amplitude } 19^{\circ} 11' \text{ South.} \end{cases}$

Here are both the Legs given; that is the Leg SI $36^{\circ} 17'$ the Latitude, and the Leg SR $70^{\circ} 49'$ the Complement of the Sun's Amplitude; which Triangle is made by Problem 14. of Spheric Trigonometry Geometric, in page 127, and its Solution is (by Chapter 5. Section 4. Problem 5. Cases 13 and 14. of Spheric Trigonometry Rectangular, in pages 139 and 140,) in this manner.

1. For the Sun's Declination, thus;

As Radius $\cdot$ S.c. Latitude $::$ S. $\odot$ Ampli. $\cdot$ S. $\odot$ Declinat. req.

As S. 90° $\cdot$ S. $53^{\circ} 43'$ $::$ S. $19^{\circ} 11'$ $\cdot$ S. $15^{\circ} 21'$ South.

2. For his Ascensional Difference, thus;

As T.c. $\odot$ Am $\cdot$ Radius $::$ S. Latitude $\cdot$ T. $\odot$ Ascen. Differ. Or

As Radius $\cdot$ S. Latit. $::$ T. $\odot$ Ampli. $\cdot$ T. $\odot$ Asc. Differ.

As 90° deg. $\cdot$ S. $36^{\circ} 17'$ $::$ T. $19^{\circ} 11'$ $\cdot$ T. $11^{\circ} 38'$ or ch $47'$.

Problem 9. The Sun's Declination, and Amplitude given; to find the Latitude, and Sun's Ascensional Difference?

Example. The Sun's $\begin{cases} \text{Declination} \text{ --- } 19^{\circ} 10' \text{ South.} \\ \text{Amplitude} \text{ --- } 31^{\circ} 30' \text{ South.} \end{cases}$

Here

Here is the Hypotenuse, and one Leg given; for which see *Problem 10. of Spheric Trigonometry Geometric*, (in page 123, *Chapter 5. Section 4. Problem 1. Cases 2, and 3. of Spheric Trigonometry Rectangular*, in pages 135 and 136) for its Solution.

Note; the Latitude may be either North, or South, in this Problem.

Problem 10. Sun's Declination, and Ascensinal Difference given; to find the Latitude, and his Amplitude?

Example. The { Sun's Declination ——— 23d. 30m. South,
Sun setteth at ——— 3h. 30m.

Here is the Hypotenuse and one Angle given; for which see *Problem 11. of Spheric Trigonometry Geometric*, (in pages 124 & 125, and *Chapter 5. Section 4. Prob. 2. Cases 4 and 5. of Spheric Trigonometry Rectangular*, in pages 136 & 137.) For its solution. *Problem 11.* Sun's Amplitude, and Ascensional Difference given; to find the Latitude and his Declination?

Example. The { Sun's Amplitude ——— 33d. 20m. North,
Sun setteth at ——— 7h. 47m.

Here is one Leg, and its opposite Angle given, for which see *Problem 13. of Spheric Trigonometry Geometric*, (in page 126, and *Chapter 5. Section 4. Problem 4. Cases 10 and 12. of Spheric Trigonometry Rectangular*, in pages 138 and 139) For the Proportions.

Problem 12. The Latitude of a Place, and the Sun's Declination given; to find his Altitude, and Azimuth at the Hour of Six?

Definition 1. Altitude is an Arch of an Azimuth Circle, contained between the Horizon and any Parallel of Altitude; as b f. Plate 7. Figure 2.

2. *Azimuth*, is an Arch of the Horizon, contained between the Meridian of the Place, and any Azimuth Circle; Or contained between the Prime Vertical, and any other Azimuth Circle; as A b. Plate 7. Figure 2.

Example. The { Latitude ——— 51d. 32m. } North.
Sun's Declination ——— 23d. 30m. }

Note; At 6 of the Clock the Sun is upon the Axis P A I.

In the Rectangle Spheric Triangle A b f (Plate 7. Fig. 2.) It is to be noted.

1. A b f the Rectangle.
2. b A f the Latitude of the Place,
3. A f the Sun's Declination, of the same Name with the Latitude.
4. b f the Sun's Altitude at the Hour of Six.

5. A b

5. Ab the Sun's Azimuth from the East at 6 in the Morning, and from the West at 6 in the Afternoon: Northerly in North Latitudes, but Southerly in South Latitudes.

To project it Stereographically, on the Plane of the Meridian.

1. Having described the Primitive Circle, quarter'd it, drawn the Axis of the World PAI, the Equinoctial EAQ , and the Parallel of Declination EOLfRg ; as before directed in Problem 4, of this Chapter, in pages 216 and 217.

2. Through f (where the Parallel of Declination cutteth the Axis PAI) draw an Oblique Circle perpendicular to the Horizon SAB (by Problem 5. Case 3. of *Spheric Geometry*, in pages 114 and 115) as is the Azimuth Circle ZfbN, to cut SAB in b, which forms the Rectangle Triangle Abf, and it's done.

For the Leg Ab, the Sun's Azimuth, and the Leg bf, the Sun's Altitude at 6 of the Clock, are the two things required, and are measured by Problem 7. Cases 2 and 3. of *Spheric Geometry*, in pages 117 and 118.

But by *Spheric Trigonometry*, having the Hypotenuse and one Angle given, that is, Af 23d. 30m. the Sun's Declination, and bAf 51d. 32m. the Latitude; the Leg bf the Sun's Altitude, and Leg Ab his Azimuth at 6 of the Clock; are found by Chapter 5. Section 4. Problem 2. Cases 4 and 5. of *Spheric Trigonometry Rectangular*, in pages 136 and 137.

1. To find the Sun's Altitude at Six, the Proportion is;

As the Radius, is to the Sine of the Latitude; so is the Sine of the Sun's Declination, to the Sine of the Sun's Altitude, at the Hour of Six. Or thus;

As Radius .. S. Angle bAf :: S. Hypot. Af .. S. Leg bf.

As S. 90d. .. S. 51d. 32m. :: S. 23d. 30m. .. S. 18d. 12m.

2. To find the Sun's Azimuth, the Proportion by the aforesaid Problem, is,

As the Radius, is to the Sine Complement of the Latitude; so is the Tangent of the Sun's Declination, to the Tangent of the Sun's Azimuth from the East, or West, at the Hour of Six. Or thus;

As Radius .. S. c. Angle bAf :: T. Hypot. Af .. T. Leg Ab.

As S. 90d. .. S. 38d. 28m. :: T. 23d. 30m. .. T. 15d. 08m.

That is,

At 6 in the Morning the Sun is E. 15d. 08m. N. or near upon the ENE. $\frac{1}{4}$ E. Point of the Compass; and at 6 in the Afternoon he is nearly upon the WNW. $\frac{1}{4}$ W. Point of the Compass.

In

In the same Triangle *A b f* (*Plate 7. Fig. 2.*) may be resolved the five Problems next following, to exercise the young Learner.

Problem 13. The Latitude, and Sun's Altitude at the Hour of Six given; to find his Declination, and Azimuth?

Example. The $\begin{cases} \text{Latitude} \text{ --- } 35^{\circ} 20' \text{ South.} \\ \text{Sun's Altitude} \text{ --- } 9^{\circ} 50' \text{ P.M.} \end{cases}$

Here is one Leg and its opposite Angle given; that is, the Leg *b f* $9^{\circ} 50'$ the Sun's Altitude, and the Angle *b A f*, $35^{\circ} 20'$ the Latitude; which Triangle is made by *Problem 13.* of *Spheric Trigonometry Geometric*, in *page 126*; and for its Solution, see *Chapter 5. Section 4. Problem 4. Cases 10 and 12*, in *pages 138 and 139*. And it's thus;

1. For the Sun's Declination, the Proportion is;

As S. Latitude .. Radius :: S. $\odot$ Alt. at 6 .. S. $\odot$ Declin.

As S. $35^{\circ} 20'$.. S. $9^{\circ} 50'$:: S. $9^{\circ} 50'$.. S. $17^{\circ} 10'$ South.

2. For the Sun's Azimuth at 6, the Proportion is;

As Radius .. T.c. Latitude :: T. $\odot$ Alt. at 6 .. S. $\odot$'s Azimuth.

As T. 45° .. T. $54^{\circ} 40'$:: T. $9^{\circ} 50'$.. S. $14^{\circ} 9'$ W. Southerly, or WSW. $\frac{1}{4}$ W. is the Point of the Compass the Sun is upon.

Problem 14. Latitude, and Sun's Azimuth at the Hour of Six given; to find his Declination, and Altitude?

Example. The $\begin{cases} \text{Latitude} \text{ --- } 36^{\circ} 19' \text{ North.} \\ \text{Sun's Azimuth} \text{ --- } 10^{\circ} 14' \text{ W. Northerly.} \end{cases}$

Here is a Leg and it's adjacent Angle given; that is, the Leg *A b* $10^{\circ} 14'$ the Sun's Azimuth, and the Angle *b A f* $36^{\circ} 19'$ the Latitude; which Triangle is made by *Problem 12.* of *Spheric Trigonometry Geometric*, in *page 125*, and for its Solution, see *Chapter 5. Section 4. Problem 3. Case 7*, and *9*, in *pages 137 and 138*. Which is thus;

1. For the Sun's Declination, the Proportion is;

As T. $\odot$ Azim. .. Radius :: S.c. Latitude .. T.c. $\odot$ Decli. Or,

As S.c. Latitude .. Radius :: T. $\odot$ Azimuth .. T. $\odot$ Dec.

As S. $53^{\circ} 41'$.. S. 90° :: T. $10^{\circ} 14'$.. T. $12^{\circ} 38'$ N.

2. For the Sun's Altitude at 6, the Proportion is;

As T.c. Latitude .. Radius :: S. $\odot$ Azim. .. T. $\odot$ Altitude, Or,

As Radius .. S. $\odot$ Azimuth :: T. Latitude .. T. $\odot$ Altit. at 6.

As S. 90° .. S. $10^{\circ} 14'$:: T. $36^{\circ} 19'$.. T. $7^{\circ} 26'$ Alt. at 6.

Problem 15. The Sun's Declination, and Altitude at the Hour of Six given: to find the Latitude, and his Azimuth?

Exam-

Example. The Sun's $\left\{ \begin{array}{l} \text{Declination} — 21^{\text{d.}} 30^{\text{m.}} \text{ South.} \\ \text{Altitude} — 15^{\text{d.}} 56^{\text{m.}} \text{ AM.} \end{array} \right.$

Here is the Hypotenuse and one Leg given; that is, A f 21^{d.} 30^{m.} the Sun's Declination, and b f 15^{d.} 56^{m.} the Sun's Altitude; for which see *Problem 10.* of *Spheric Trigonometry Geometric*, in Page 123. and Chapter 5, Section 4, Problem 1, Cases 2 and 3, of *Spheric Trigonometry Rectangular*, in Pages 135 and 136.

Problem 16. Sun's Declination, and his Azimuth at the Hour of Six given; to find the Latitude, and his Altitude?

Example. The Sun's $\left\{ \begin{array}{l} \text{Declination } 19^{\text{d.}} 24^{\text{m.}} \text{ South.} \\ \text{Azimuth } 10^{\text{d.}} 09^{\text{m.}} \text{ E. S. erly.} \end{array} \right.$

Here is (as in the last Problem) the Hypotenuse and one Leg given; that is, A f 19^{d.} 24^{m.} the Sun's Declination, and A b 10^{d.} 09^{m.} the Sun's Azimuth; for which see Problem 10, of *Spheric Trigonometry Geometric*, in page 123. and Chapter 5, Section 4, Problem 1, Cases 1 and 3, of *Spheric Trigonometry Rectangular*, in pages 135 and 136.

Problem 17. Sun's Azimuth, and Altitude at the Hour of Six given; to find the Latitude, and his Declination?

Example. The Sun's $\left\{ \begin{array}{l} \text{Azimuth } 16^{\text{d.}} 10^{\text{m.}} \text{ W. Southerly.} \\ \text{Altitude } 9^{\text{d.}} 00^{\text{m.}} \end{array} \right.$

Here are both Legs given; for which see Problem 14. of *Spheric Trigonometry Geometric*, in page 127. and Chapter 5, Section 4, Problem 5, Cases 13 and 14 of *Spheric Trigonometry Rectangular*, in pages 139 and 140.

Problem 18. The Latitude of a Place, and the Sun's Declination given; to find the Sun's Altitude, and the Hour of the Day when the Sun is East or West.

Note; When the Sun is either East or West, he is then upon the Prime Vertical, ZAN, Plate 7. Figure 2.

Example. The $\left\{ \begin{array}{l} \text{Latitude} ————— 51^{\text{d.}} 32^{\text{m.}} \\ \text{Sun's Declination} — 23^{\text{d.}} 30^{\text{m.}} \end{array} \right. \text{North.}$

In the *Rectangle Spheric Triangle* Akl, Plate 7. Fig. 2. Observe, That,

1. A k l is the Rectangle.
2. k A l the Latitude.
3. k l the Sun's Dec. of the same Name with the Lat.
4. A l the Sun's Altitude when he is upon the East or West Azimuth Circle.
5. A k the Hour from 6; if East, after 6 in the Forenoon, but when West, before 6 Afternoon.

To project it *Stereographically* on the Plain of the Meridian.

1. The Primitive Circle being drawn, quartered, as also the

the Axis PAI , Equinoctial $\mathcal{E}AQ$, and Parallel of Declination $\odot I R g$, as formerly, in Problem 4. of this Chapter, to cut the Prime Vertical ZAN in I , the Place of the Sun when he is either East or West.

2. Then thro' I draw a Great Circle, to cut the Equinoctial $\mathcal{E}AQ$ at Right Angles in k , by Problem 5. Case 3. of *Spheric Geometry*, in page 115, as the Oblique Circle $PIkI$, which forms the Rectangle Spheric Triangle AkI .

For the Hypotenuse AI , and Leg Ak , (the former the Sun's Altitude, the latter the Hour from 6, when he is either East, or West,) are the two Things required, and are measured by Problem 7, Case 2, of *Spheric Geometry*, in page 118.

But by *Trigonometry*, having a Leg and its opposite Angle given; that is, kAI 51d. 32m. the Latitude; and kI , 23d. 30m. the Sun's Declination: The Leg Ak the Hour from 6, and the Hypotenuse AI , the Sun's Altitude when East, or West, are found by Chapter 5, Section 4, Problem 4, Cases 10 and 12 of *Spheric Trigonometry*, in pages 138 and 139. Thus,

1. To find the Sun's Altitude, the Proportion is,

As the Sine of the Latitude, is to the Radius;

So is the Sine of the Sun's Declination, to the Sine of his Altitude, when East, or West. Or thus;

As S. Angle KAI .. Radius :: S. Leg kI .. S. Hypot. AI .

As S. 51d. 32m. .. S. 90d. :: S. 23d. 30m. .. S. 30d. 37m. $\odot Alt$.

2. To find the Hour from Six, the Proportion by the afore-said Problem 4, and Case 10, is;

As the Radius, is to the Tangent Complement of the Latitude;

So is the Tangent of the Sun's Declination, to the Sine of the Hour from Six. Or thus;

As Radius .. T.c. Angle AkI :: T. Leg kI .. S. Leg Ak .

As T. 45d. .. T. 38d. 28m. :: T. 23d. 30m. .. S. 20d. 13m. the Hour from Six.

Which reduced into Hours and Minutes of Time, and added to, and subtracted it from 6 Hours, giveth the Hour of the Day required.

That is, 20d. 13m. reduced into Time, is 1h. 21m. almost,
Which added to ————— 6h. 00m.

The Sum sheweth the Sun is East at ——— 7h. 21m. Morn.

And being subtr. sheweth the Sun is West 4h. 39m. Aftern.

In the same Rectangle Spheric Triangle AkI , (Plate 7. Figure 2.) the five Problems following may be resolved, to exercise the Learner.

Prob.

Problem 19. The Sun East, the Latitude, and the Sun's Altitude given; to find his Declination and the Hour of the Day?

Example The $\left\{ \begin{array}{l} \text{Latitude} \text{ --- } 51^{\circ}. 30^{\text{m}}. \text{ North.} \\ \text{Sun's Altitude, --- } 25^{\circ}. 16^{\text{m}}. \text{ Morning.} \end{array} \right.$

Here is the Hypotenuse, and one Angle given; that is the Hypotenuse Al $25^{\circ}. 16^{\text{m}}$. the Sun's Altitude, and the Angle kAl $51^{\circ}. 30^{\text{m}}$. the Latitude: which Triangle is made by Problem 11. of *Spheric Trigonometry Geometric*, in page 124, and for its Resolution, see Chapter 5. Section 4. Problem 2. Cases 4 and 5. in pages 136 and 137. And,

1. For the Sun's Declination, the Proportion is;
As Radius .. S. Latitude :: S. $\odot$ Altitude. .. S. $\odot$ Declin. Req.
As S. 90° .. S. $15^{\circ}. 30^{\text{m}}$. :: S. $25^{\circ}. 16^{\text{m}}$. .. S. $19^{\circ}. 30^{\text{m}}$. Nor.
2. For the Hour when he is East, the Proportion is;
As T.c. $\odot$ Alt. .. Rad. :: Sc. Lat. .. T. Hour from 6, when E. Or,
As Radius .. S. c. Lat. :: T. $\odot$ Alt. .. T. Hour from 6, when E.
As 90° .. S. $38^{\circ}. 30^{\text{m}}$. :: T. $25^{\circ}. 16^{\text{m}}$. .. T. $16^{\circ}. 20^{\text{m}}$. or $1^{\text{h}}. 5^{\text{m}}$.
which added to 6, makes $7^{\text{h}}. 5^{\text{m}}$. the Time when the Sun is East.

Problem 20. The Sun West, the Latitude, and Hour of the Day given; to find the Sun's Altitude, and Declination?

Example. The $\left\{ \begin{array}{l} \text{Latitude} \text{ --- } 30^{\circ}. 10^{\text{m}}. \text{ South} \\ \text{Hour} \text{ --- } 3^{\text{h}}. 15^{\text{m}}. \text{ P. M. or Afternoon.} \end{array} \right.$

Here is given a Leg, and it's adjacent Angle; that is, the Leg Ak $41^{\circ}. 15^{\text{m}}$. or $2^{\text{h}}. 45^{\text{m}}$. the Hour from 6, when the Sun is West; and the Angle kAl $30^{\circ}. 10^{\text{m}}$. the Latitude; which Triangle is made by Problem 12. of *Spheric Trigonometry Geometric*. And for its Resolution, see Chapter 5. Section 4. Problem 3. Cases 7 and 9. In pages 137 and 138. And,

1. For the Sun's Declination, the Proportion is,
As T.c. Lat. .. Radius :: S. Hour from 6 .. T. $\odot$ Declination. Or,
As Radius .. S. Hour from 6 :: T. Latitude .. T. Sun's Declination
As S. 90° .. S. $41^{\circ}. 15^{\text{m}}$. :: T. $30^{\circ}. 10^{\text{m}}$. .. T. $20^{\circ}. 58^{\text{m}}$. South.
2. For the Sun's Altitude, the Proportion is,
As T. Hour from 6 .. Rad. :: S. c. Lat. .. T. c. $\odot$ Alt. when W. Or
As S. c. Lat. .. Radius :: T. Hour from 6 .. T. Sun's Alt. when W.
As S. $59^{\circ}. 50^{\text{m}}$. .. S. 90° . :: T. $41^{\circ}. 15^{\text{m}}$. .. T. $45^{\circ}. 23^{\text{m}}$.
the Sun's Altitude, when West.

Problem 21. The Sun East, his Declination, and his Altitude given; to find the Latitude, and Hour of the Day?

Example. The Sun's $\left\{ \begin{array}{l} \text{Declination} \text{ } 2^{\circ}. 50^{\text{m}}. \text{ South.} \\ \text{Altitude} \text{ --- } 29^{\circ}. 30^{\text{m}}. \text{ A. M. or Morn.} \end{array} \right.$
P Here

Here is given the Hypotenuse, and one Leg; that is, the Hypotenuse Al 29d. 30m. the Sun's Altitude, and the Leg kl 20d. 50m. his Declination: Which Triangle is made by Problem 10. of *Spheric Trigonometry Geometric* in page 122. and for it's Resolution, see Chapter 5. Section 4. Problem 1. Cases 2 and 3; in pages 135 and 136.

Problem 22. The Sun West, his *Declination*, and Hour of the Day given; to find the *Latitude*, and his *Altitude*?

Example. The $\left\{ \begin{array}{l} \text{Sun's Declination 10d. 39m. North.} \\ \text{Hour of the Day 4h. 52m. P. M.} \end{array} \right.$

Here are given both Legs; that is, the Leg kl 10d. 39m. the Sun's Declination; and Leg Ak 17d. or 1h. 8m. the Hour from 6, when the Sun is West: for making this Triangle, see Problem 14. of *Spheric Trigonometry Geometric* in page 127. And for its Resolution see Chapter 5. Section 4. Problem 5. Cases 13 and 14. in pages 139 and 140.

Problem 23. The Sun East, his *Altitude*, and the Hour of the Day given; to find the *Latitude*, and his *Declination*?

Example. The $\left\{ \begin{array}{l} \text{Sun's Altitude ——— 30d. 10m.} \\ \text{Hour of the Day ——— 7d. 50m. A. M.} \end{array} \right.$

Note; In this Problem the Latitude may be either North or South, and truly answer the Question.

Here is given the Hypotenuse, and one Leg; that is, the Hypotenuse Al 30d. 10m. the Sun's Altitude when East, and the Leg Ak 27d. 30m. or 1h. 50m. the Hour from 6, when he is so; this Triangle is made by Problem 10. of *Spheric Trigonometry Geometric*, in page 123, and for its Resolution, see Chapter 5. Section 4. Problem 1. Cases 1 and 3. in pages 135 and 136.

Problem 24. The Sun in the *Equinoctial*, the *Latitude* of a Place, and the Sun's *Altitude* given; to find his *Azimuth*, and the Hour of the Day?

Note; When the Sun hath no Declination, he is then (said to be) in the Equinoctial; which is twice in a Year, about the 30th of *March*, and the 12th of *September*.

Example. The $\left\{ \begin{array}{l} \text{Latitude} \text{ --- } 51^{\circ} 32' \text{ North.} \\ \text{Sun's Altitude } 21^{\circ} 50' \text{ AM. (or Morning.)} \end{array} \right.$

In the Rectangle Spheric Triangle $Z \text{ } \Delta \text{ } D$, *Plate 7. Fig. 2.* it is to be noted ;

1. The Leg $Z \text{ } \Delta \text{ } D$ the Rectangle.
2. The Leg $Z \text{ } \Delta$ the Latitude of the Place.
3. The Leg $\Delta \text{ } D$ the Hour of the Day from Noon.
4. The Angle $Z D$ the Complement of the Sun's Altitude.
5. $\Delta Z D$ the Sun's Azimuth from the South in North Latitude ; but from the North in South Latitude, Easterly in the Forenoon, and Westerly in the Afternoon.

To project it Stereographically on the Plane of the Meridian.

1. The Primitive Circle being drawn, quartered, as also the Axis PAI , and the Equinoctial $A \text{ } \Delta \text{ } Q$ as formerly directed in *Problem 4.* in page 216.

2. By *Problem 9. Case 2. of Spheric Geometry*, in page 121. draw a parallel Circle at $21^{\circ} 50'$ (the given Altitude,) distance from the Horizon SAB , as AD it, to cut the Equinoctial $\Delta \text{ } \Delta \text{ } Q$, in D ; the Place of the Sun at that Time.

3. Through D (by *Problem 5. Case 3. of Spheric Geometry*, in page 115 :) draw a Great Circle perpendicular to SAB , as is the Oblique Circle $ZDCN$, which concludes the Rectangle Spheric Triangle $Z \text{ } \Delta \text{ } D$, and it's done.

For the Angle $\Delta Z D$, and Leg ΔD ; (the former the Sun's Azimuth from the South Meridian, the latter the Hour from Noon, when the Sun is in the Equinoctial,) are the two things required, and are measured by *Problem 7. Case 2.* and *Problem 8. Case 2. of Spheric Geometry* in pages 118 and 119.

But by Spheric Trigonometry, having the Hypotenuse, and one Leg given ; that is, ZD $78^{\circ} 10'$ the Complement of the Sun's Altitude, and $Z \text{ } \Delta$ $51^{\circ} 32'$ the Latitude : The Angle $\Delta Z D$ the Sun's Azimuth, and Leg ΔD the Hour from Noon, are found by *Chapter 5. Section 4. Cases 1. and 2. of Spheric Trigonometry Rectangular*, in pages 135 and 136. And;

1. To find the Sun's Azimuth, the Proportion is ;

As the Radius, is to the Tangent of the Latitude ;

So is the Tangent of the Sun's Altitude, to the Sine Complement of the Sun's Azimuth from the South. Or thus ;

$P 2$

$A 3$

As Radius .. T. Leg $Z\bar{A}E$:: T.c. Hypot. ZD .. S.c. Angle $\bar{A}EZD$.

As T. 45d. .. T. 51d. 32d. :: T. 21d 50m. .. S. 30d. 17m.

Which subtract from _____ 90d. 00m.

Remainder is the Sun's Azimuth, South _____ 59d. 43m.

Easterly, that is S. E. by E. $\frac{1}{4}$ E. is the point of the Compass the Sun is upon.

2. To find the Hour, the Proportion by the foresaid Problem

1. Case 3. is :

As the Sine Complement of the Latitude, is to the Radius ;

So is the Sine of the Sun's Altitude, to the Sine Complement of the Hour from Noon. Or thus ;

As S.c. Leg $Z\bar{A}E$.. Radius :: S.c. Hypot. ZD .. S.c. Leg $\bar{A}ED$.

As S. 38d. 28m. .. S. 90d. :: S. 21d. 50m. .. S. 36d. 43m.

Which subtract from _____ 90d. 00m.

Remainder is the Hour from Noon _____ 53d. 17m.

Which is equal to 3h. 33m. the Hour from Noon, therefore the Hour of the Day is 8h. 27m. in the Morning.

In the same Rectangle Spheric Triangle $Z\bar{A}ED$ might five Problems more be resolved, which I leave for the Learner to invent, and so pass on to *Oblique Spheric Triangles* in *Astronomy*.

Section III. *Oblique Spheric Triangles*, applied in *Astronomic Problems*, useful in *Navigation*.

IN the last Section, Rectangle Spheric Triangles were applied to Problems of *Astronomy*; now in like manner Oblique Spheric Triangles shall be applied, both them and the following being very useful in *Navigation*.

Problem 1. *The Latitude of a Place, the Sun's Declination, and his Altitude given; to find his Azimuth, and the Hour of the Day?*

Example. The $\left\{ \begin{array}{l} \text{Latitude} \text{ --- } 51^{\circ} 30' \\ \text{Declination} \text{ --- } 15 \quad 10 \\ \text{Altitude} \text{ --- } 11 \quad 30 \end{array} \right\}$ Sun's } North.

In the Oblique Spheric Triangle $PZ\odot$. Plate 7. Figure 2. is to be Noted.

1. The Side ZP the Complement of the Latitude.

2. The Side $Z\odot$ the Complement of the Sun's Altitude.

3. The Side $P\odot$ the Sun's Distance from the Elevated Pole, which is the Declination added to 90 Degrees, when the Latitude and Declination are of a contrary Name; But if of one Name, it's the Complement of the Declination.

4. The

4. The Angle $PZ\odot$ the Sun's Azimuth from the North, in North Latitude; but from the South, in South Latitude.

5. The Angle $ZP\odot$ the Hour of the Day from Noon.

To project it *Stereographically*, on the Plane of the Meridian.

1. Having drawn the Primitive Circle and quarter'd it, also draw the Axis PAI , and the Equinoctial $\mathcal{E}AQ$, and the Parallel of Declination $\odot I f R g$.

2. Draw (by Problem 9. Case 2. of *Spheric Geometry*, in page 121.) a parallel Circle, parallel to the Horizon SAB , at 11d. 30m. (the Sun's Altitude) distance from it, to cut the parallel of Declination in $\odot$, the Place of the Sun at that time.

3. Then through $\odot$ draw two Great Circles, one through Z and N , the Poles of the Horizon; and the other through P and I the Poles of the Equinoctial; as are the Oblique Circles $Z\odot N$ and $P\odot I$; which form the Oblique Spheric Triangle $PZ\odot$, and its done.

For the Angles $PZ\odot$, and $ZP\odot$, the former the Sun's Azimuth, the latter the Hour of the Day from Noon; are the two things required, and are measured by Problem 8. Case 2. of *Spheric Geometry*, in page 119.

But by *Spheric Trigonometry*, having 3 Sides given; that is, ZP 38d. 30m. the Complement of the Latitude, $Z\odot$ 78d. 30m. the Complement of the Sun's Altitude, and $P\odot$ 74d. 50m. the Sun's Distance from the Elevated Pole; the Angle $PZ\odot$ the Sun's Azimuth, and $ZP\odot$ the Hour of the Day, are found by Chapter 5. Section 5. Problem 11. Case 11. of *Spheric Trigonometry Oblique*, in pages 147 and 148, as followeth.

1. Add the Complement of the Latitude, Complement of the Sun's Altitude, and the Sun's Distance from the Elevated Pole into one Sum.

2. From half that Sum subtract, (for finding the Sun's Azimuth,) the Sun's Distance from the Pole; But, for finding the Hour of the Day, subtract the Complement of the Sun's Altitude, noting the half Sum, and the Remainder.

5. Then to find the Sun's Azimuth, it's thus; to the Complement Arithmetic of the Sines of the Complement of the Latitude, and Complement of the Sun's Altitude, add the Sines of the aforesaid Half-Sum, and Remainder: half the Total of these four Logarithms, is the Sine of the Supplement of half the Sun's Azimuth from the North, in North Latitude; and from the South, in South Latitude.

But to find the Hour of the Day it's thus : to the Complement Arithmetic of the Sines of the Complement of the Latitude, and the Sun's Distance from the Pole, and the Sines of the said half Sum, and the Remainder : Half the Total of these four Logarithms, is the Sine of the Supplement of half the Hour from Noon, all which is shortned thus ;

1. To find the Azimuth, the Operation is ;

Side	$\left. \begin{array}{l} \text{ZP } 38^{\circ} 30' \\ \text{Z}\odot 78^{\circ} 30' \\ \text{P}\odot 74^{\circ} 50' \end{array} \right\}$	Containing Sides	$\left\{ \begin{array}{l} \text{S. co. ar.} - 0.205850 \\ \text{S. co. ar.} - 0.008807 \end{array} \right.$
	$\left. \begin{array}{l} \text{half Sum sides } 95^{\circ} 55' \\ \text{Sum is } 19^{\circ} 50' \\ \text{half Sum } 59^{\circ} 55' \end{array} \right\}$		$\left\{ \begin{array}{l} \text{S.} - 9.997680 \\ \text{Remainder } 21^{\circ} 05' \text{ S.} - 9.555971 \end{array} \right.$
	$\left. \begin{array}{l} \text{Sum of the 4 Logarithms is } 19.768308 \\ \text{Remainder } 21^{\circ} 05' \end{array} \right\}$		$\left\{ \begin{array}{l} \text{S.} - 9.884154 \\ \text{Which doubled } 49 \quad 59 \end{array} \right.$
			$\left\{ \begin{array}{l} \text{The double is } 99 \quad 58 \\ \text{Subtract from } 180 \quad 00 \end{array} \right.$

Remainder is the Sun's Azimuth $80^{\circ} 02'$ from the North.

Or by Gunter's Scale.

As Radius .. S. c. Latitude, :: S. c. $\odot$ Altitude .. a 4th Sine.

As S. 90° .. S. $38^{\circ} 30'$:: S. $78^{\circ} 30'$.. S. $37^{\circ} 35'$.

Then again,

As the 4th Sine .. S. Sum sides :: S. Remainder .. a 5th Sine.

As S. $37^{\circ} 35'$.. S. $95^{\circ} 55'$:: S. $21^{\circ} 05'$.. S. $36^{\circ} 06'$.

Against which, on the Line of Versed Sines is $80^{\circ} 02'$ the Sun's Azimuth from the North, Easterly if in the Morning, and from the North, Westerly if in the Afternoon ; that is, the Sun is near the E. by N. Point of the Compass in the Morning, and near the W. by N. Point in the Afternoon.

2. To find the Hour of the Day, the Operation is,

Side {	ZP 38d. 30m.	{ Containing Sides {	S. co. ar. — 0.205850
	CP 74d. 50m.		S. co. ar. — 0.015397
	ZC 78d. 30m.		half Sum Sides 95d. 55m. S. — 9.997080
Sum is	191d. 50m.	Remainder	17d. 25m. S. — 9.476133
half Sum is	95d. 55m.	Sum of the 4 Logarithms is	— 19.695060
Remaind.	17d. 25m.	44.45 S. half Sum	— 9.847530

Which doubled ——— 44.45

The double is ——— 89.30 Which

subtract from ——— 180.00 h. m.

Rem. is the Hour from Noon — 90.30 equal to 6 : 02

Or by Gunter's Scale.

As Radius .. S. c. Latitude, :: S. C Dist. from Pole .. a 4 Sine

As S. 90d. .. S. 38d. 30m. :: S. 74d. 50m. .. S. 36d. 56m.

Then again,

As the 4th Sine .. S. $\frac{1}{2}$ Sum sides :: S. Remainder .. a 5th Sine.

As S. 36d. 56m. .. S. 97d. 55m. :: S. 17d. 25m. .. S. 29d. 42m.

Against which, on the Line of Versed Sines, is 90d. 30m.
Or 6h. 2m. the Hour from Noon; that is, 58m. after 5 in the Morning, or 2m. after 6 in the Afternoon.

In the same Oblique Spheric Triangle ZP $\odot$, (Plate 7. Fig. 2.) may the nine Problems next following be resolved.

Problem 2. The Latitude of a Place, the Sun's Altitude, and Azimuth given; to find his Declination, and the Hour of the Day.

Example. In Latitude 51d. 32m. the Sun being 38d. 19m. above the Horizon, his Azimuth was observed to be North 107d. 47m.

Easterly. I demand the Hour of the Day, and the Sun's Decl.

Answer. The Hour of the Day is 30m. after 8, and the Declination of the Sun 19d. 39m. North.

In this Problem are two Sides, and one Angle between them given; that is, ZP 38d. 28m. the Complement of the Latitude, Z $\odot$ 51d. 11m. the Complement of the Sun's Altitude, and PZ $\odot$ 107d. 47m. his Azimuth; which Triangle is made by Prob. 18. of Spheric Trigonometry Geometric, in pages 129 and 130. and is resolved by Problem 9. Cases 7 and 8. of Spheric Trigonometry Oblique, in pages 144 and 145.

Prob. 3. The Latitude of a Place, the Sun's Declination and Azimuth given; to find his Altitude, and Hour of the Day?

Example. In Latitude 13d. 30m. North, the Sun's Declination being 9d. 58m. S. and his Azimuth N. 129d. 40m. westerly. I demand the Hour of the Day, and his Altitude?

Answer. The Hour of the Day is either 2h. 13m. and the Sun's Altitude is 57d. or else the Hour of the Day is 5h. 52m. and then his Altitude is 7d. 13m.

Here are two Sides, and one Angle opposite given, that is ZP 76d. 50m. the Complement of the Latitude, $P\odot$ 90d. 15m. the Sun's Distance from the Elevated Pole, and $PZ\odot$ 129d. 40m. his Azimuth; which Triangle is made by Problem 16. of *Spheric Trigonometry Geometric*, in pages 128 and 129. And resolved by Problem 7. Cases 2 and 3. of *Spheric Trigonometry Oblique*, in pages 142 and 143.

Problem 4. The Latitude of a Place, Sun's Altitude, and the Hour of the Day given; to find the Sun's Azimuth, and his Declination.

Example. In Latitude 30d. 51m. South, at 15m. past 3 in the Afternoon, the Sun's Altitude being 41d. 10m. I demand the Sun's Azimuth, and Declination?

Answer. The Sun's Azimuth is South 102d. 2m. Westerly, and his Declination is 11d. 41m. South.

Here are two Sides, and one Angle opposite given.

That is, ZP 59d. 09m. the Complement of the Latitude, $Z\odot$ 48d. 50m. the Complement of the Sun's Altitude, and $ZP\odot$ 48d. 45m. Or 3h. 15m. the Hour of the Day from Noon; and therefore projected, and resolved like Problem 3. aforesaid, in page 231.

Problem 5. The Latitude of a Place, the Sun's Declination, and Hour of the Day given; to find his Azimuth and Altitude?

Example. The Latitude 20d. 11m. North, the Sun's Declination 23d. 29m. South, at 9d. 24m. in the Morning: I demand the Sun's Azimuth, and what is his Altitude?

Answer. The Sun's Azimuth is South 44d. 13m. East, and his Altitude is 34d. 08m.

Here are two Sides, and one Angle between them given; That is, ZP 69d. 49m. the Complement of the Latitude, $P\odot$ 113d. 29m. the Sun's Distance from the Elevated Pole, and $ZP\odot$ 39d. or 2h. 36m. the Hour of the Day from Noon, which is wrought as before in Problem 2. page 231.

Problem 6. The Latitude of a Place, the Sun's Azimuth, and Hour of the Day given; to find the Sun's Declination and Altitude.

Example. In Latitude 13d. 10m. North, the Sun's Azimuth being observed at 24m. after 2, to be South 59d. 30m. West, I demand the Sun's Declination, and his Altitude?

Answer. The Sun's Declination is 9d. 27m. South, and his Altitude at the same time is 47d. 43m.

Here are two Angles, and one Side between them given: That is ZP 76d. 50m. the Complement of the Latitude, $PZ\odot$ 120d. 30m. the Sun's Azimuth, and $ZP\odot$ 36d. or 2h. 24m. the Hour of the Day from Noon; for the making of this Triangle, see Problem 19 of *Spheric Trigonometry Geometric*,

in page 130. And is resolved by Problem 10. Case 9. of *Spheric Trigonometry Oblique*, in page 146.

Problem 7. The Sun's Altitude, Declination, and his Azimuth given: to find the Latitude, and Hour of the Day.

Example. The Sun's Altitude being observed to be 38d. 20m. Oriental, and his Azimuth at the same time 107d. 10m. from the North, and his Declination 19d. 40m. N. I demand the Latitude of the Place of Observation, and the Hour of the Day?

Answer. The Latitude of the Place is 51d. 30m. North, and the Hour of the Day is 30m. after 8 in the Morning.

Here are two Sides, and one Angle opposite given; that is $Z\odot$ 51d. 40m. the Complement of the Sun's Altitude, $P\odot$ 70d. 20m. his Distance from the Elevated Pole, and $PZ\odot$ 107d. 10m. his Azimuth from the North, which Triangle is made and wrought as before, in Problem 3. of this Section, in page 232.

Problem 8. The Sun's Altitude, his Declination, and Hour of the Day given; to find his Azimuth, and the Latitude.

Example. At 5h. 42m. in the Morning, observing the Sun 12d. 30m. above the Horizon, and his Declination being 19d. 40m. North. I demand the Latitude of the Place, and the Sun's Azimuth?

Answer. The Latitude is 51d. 32m. North, and the Sun's Azimuth North 74d. 05m. Easterly, or ENE. half E. almost.

Here are two Sides, and one Angle opposite given; that is, $Z\odot$ 77d. 30m. the Complement of the Sun's Altitude, $P\odot$ 70d. 20m. his Distance from the Elevated Pole, and $ZP\odot$ 94d. 30m. or 6h. 18m. the Hour of the Day from Noon; which Triangle is made and wrought as before in Problem 3. of this Section, in page 232.

Problem 9. The Sun's Altitude, his Azimuth, and the Hour of the Day given; to find the Sun's Declination, and the Latitude of the Place.

Example. Observing the Sun 12d. 30m. above the Horizon at 18m. past 6 a Clock Afternoon, and his Azimuth 74d. from the North. I demand the Latitude, and the Sun's Declination?

Answer. Latitude is 51d. 30m. North, and Sun's Declination is 19d. 40m. North.

Here are two Angles and one Side opposite given; that is, $Z\odot$ 77d. 30m. the Complement of the Sun's Altitude, $PZ\odot$, 74d. the Sun's Azimuth from the North, and $ZP\odot$ 94d. 30m. or 6h. 18m. the Hour from Noon; which Triangle is made by Problem 17. of *Spheric Trigonometry Geometric*, and is resolved by Problem 8. Cases 4. and 5. of *Spheric Trigonometry Oblique*, in pages 143 and 144.

Problem

Problem 10. The Sun's Declination, his Azimuth, and Hour of the Day given; to find his Altitude and the Latitude of the Place.

Example. The Sun's Declination 19d. 40m. N. and at half an Hour past 8 of the Clock in the Morning his *Azimuth* was observed to be 107d. 50m. from the North, I demand the *Latitude* of the Place of Observation, and what was the Sun's Altitude?

Answer. The Latitude is 51d. 30m. North, and the Sun's Altitude is 38d. 18m.

Here are two Angles and one side opposite given, as before in the last Problem: That is, $PO \odot$ 70d. 20m. the Sun's Distance from the elevated Pole, $PZ \odot$ 107d. 48m. his Azimuth from the North, and $ZP \odot$ 52d. Or 3h. 28m. the Hour of the Day from Noon; which Triangle is made and wrought like **Problem 9.** the last foregoing.

Problem 11. The Latitude and Longitude of a Star, and the Obliquity of the Ecliptic given, to find the Right Ascension, and Declination of that Star?

Definition 1. Latitude of a Star, is an Arch of a Circle of Longitude, contained between the Star's Center and the Ecliptic.

2. Longitude of a Star, is an Arch of the Ecliptic, contained between the beginning of *Aries*, and that Circle of Longitude which passeth over the Star's Center, and counted according to the Succession of the Signs.

Example.

Capella, or the Goat, the $\left\{ \begin{array}{l} \text{Latitude} \text{ --- } 22\text{d. } 52\text{m North} \\ \text{Longitude} \text{ --- } 18\text{d. } 02\text{m. in } \Pi. \end{array} \right.$

In the Oblique Spheric Triangle PKD, *Plate 7. Figure 1.* is to be noted.

1. PK the Distance of the Pole of the Ecliptic from the Pole of the World, equal to the Ecliptic's Obliquity 23d. 30m.

2. KD the Complement of the Star's Latitude, or its Distance from one Pole of the Ecliptic.

3. PD the Complement of the Star's Declination, or its Distance from the agreeing Pole of the World.

4. PKD the Star's Longitude from $\odot$, if the Star's Latitude be North, but from ϖ , if it be South; that is, from $\odot$, if the Ecliptic's North Pole be one Angle; but from ϖ if its South Pole be one Angle of the Triangle.

5. KPD the Star's Right Ascension from ϖ , if its Latitude be North; but from $\odot$, if its Latitude be South: That is, if the Ecliptic's North Pole be one Angle, &c. as before in the 4th Step.

○

Here

Here are two sides, and one Angle between them given ;
That is, PK 23d. 20m. the Distance of the North Poles of the
Equinoctial and Ecliptic, KD 67d. 08m. the Complement of
the Star's Latitude, and PKD 11d. 58m. the Star's Longitude
from (wanting of) Cancer ; which Triangle is made by *Problem*
18. of *Spheric Trigonometry Geometric, Chapter 5. Section 5.* in
pages 129 and 130. And by *Problem 9. Cases 7 and 8,* in
pages 144 and 145. the Proportions are as follow,

First, To find the Star's Right Ascension,

	d.	m.
1. As S. half Sum of the sides KD and KP	45	19
Is to S. half their Difference	21	50
So is T. c. of half the Angle PKD	84	01
To T. half Diff. of the Angles DPK and PDK	78	40
2. As S. c. half Sum of the sides KD and KP	44	41
Is to S. c. half Difference	68	10
So is T. c. of half the Angle PKD	84	01
To T. half Sum of the Angles DPK and PDK	85	27
Unto which add their half Difference before found	78	40
And it giveth the Angle KPD	164	07
From which subtract AQ	90	00
Remainder is AM the Star's Right Ascension	74	07

from the beginning of *Aries*.

Secondly, For the Star's Declination,

	d.	m.
As S. KPD Star's Right Ascension from <i>Capricorn</i>	164	07
Is to S. KD its Complement of Latitude	67	08
So is S. PKD its Longitude from <i>Cancer</i>	11	58
To S.PD its Complement of the Star's Declination	44	19
Wherefore the Star's Declination is North	45	41

Problem 12. The Right Ascension of the Sun, and Right Ascension of a Star given; to find the Time of the Star's coming to, or upon the Meridian.

The Rule, Subtract the Sun's Right Ascension from the Star's Right Ascension, the Remainder reduced into Time, is the Time of the Star's coming upon, or to the Meridian, Afternoon.

Note ; If you cannot subtract, add 360 Degrees to the Star's Right Ascension, and then subtract.

Example. The 5th of October 1744; I demand at what time Aldebaran or the Bull's Eye, cometh to the Meridian?

The

d. m.

The { 5th of October, the Sun's Declination is 9 5 S. increase.
 { Latitude { of Aldebaran is { _____ 5 30 South.
 { Longitude { _____ 5 57 in Gemini.

And therefore you may find that,

d. m.

By Sect. { 3. { Prob. } 3. { the { Star's } Right Asc. is { 65 03
 { 2. { } 11. { the { Sun's } } { 201 34

Then add 360d. to 65d. 03m. the Star's Right Ascension, and it is 425d. 03. from which subtract 20d. 43m. the Sun's Right Ascension, the Remainder is 223d. 29m. which maketh 14h. 54m. the Star's coming to the Meridian after Noon, that is 54m. after Two in the Morning.

And thus having found the Right Ascension, Declination, and Time of any Star's coming upon the Meridian, you may by Problem 4. Section 2. of this *Chapter*, find it's Amplitude, and Ascensional Difference, and thereby its Rising and Setting; its Distance from the Meridian at any Altitude, observed by Problem 1. Section 3. of this *Chapter*, in page 229, and so the Hour of the Night thereby; all which I leave for the Exercise of those that are learning these Things.

Section IV. *The Doctrine of the Sphere, or Spheric Trigonometry, applied in sundry Astronomic Problems, useful in Navigation, according to the Pythagorean System.*

THE *Pythagorean System of the World*, lately revived by *Copernicus*, is now generally received by the most, and best Astronomers; it being indeed the most agreeable to the Motion of the Heavenly Bodies, confirmed by Experience in the constant Observation of them, in which these are Fundamental Principles.

1. That the Earth is carried round the Sun in a large Orb or Path, betwixt the Orbs of the Planets *Mars* and *Venus*, once in a Year.

2. That besides this Annual Motion, the Earth turns round her own Axis once in 24 Hours.

3. And that the said Axis of the Earth, is inclined to the Plane of her Orb at the same Angle, and keeps in all Parts of it, nearly parallel to it self.

On these Assertions, but chiefly the Second, to wit, the Diurnal Motion of the Earth about its own Axis, once in 24 Hours, whereby all the visible Appearances of the Sun, and
 Fixed

Plate 7
Fig: II

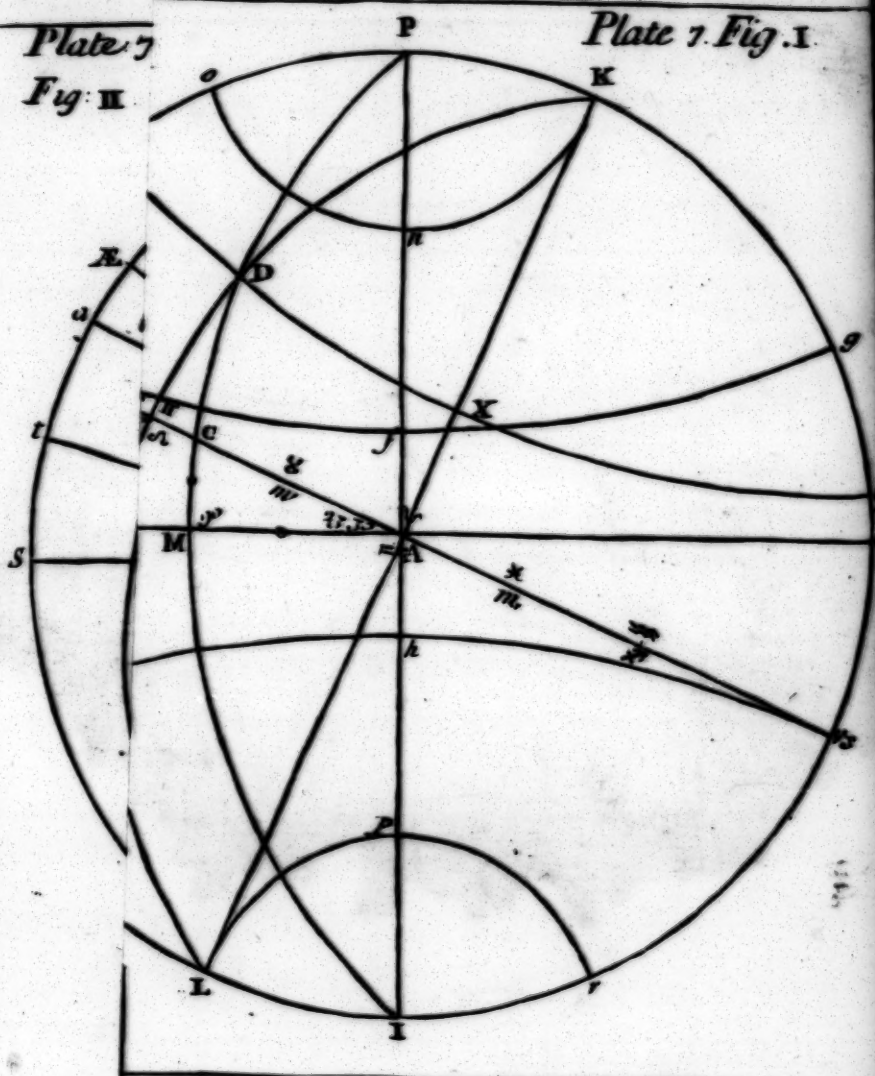


Plate 7. Fig. I.

Plate 7.

Fig. II

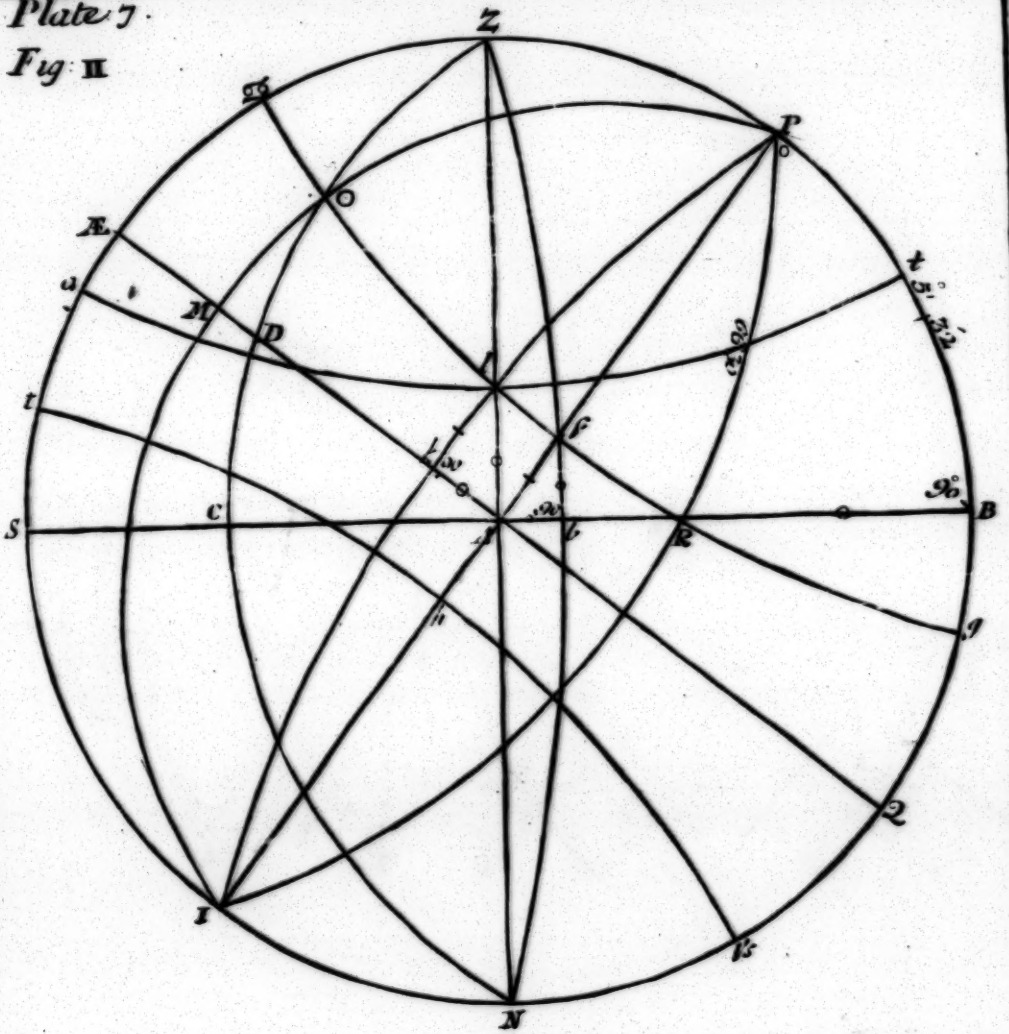
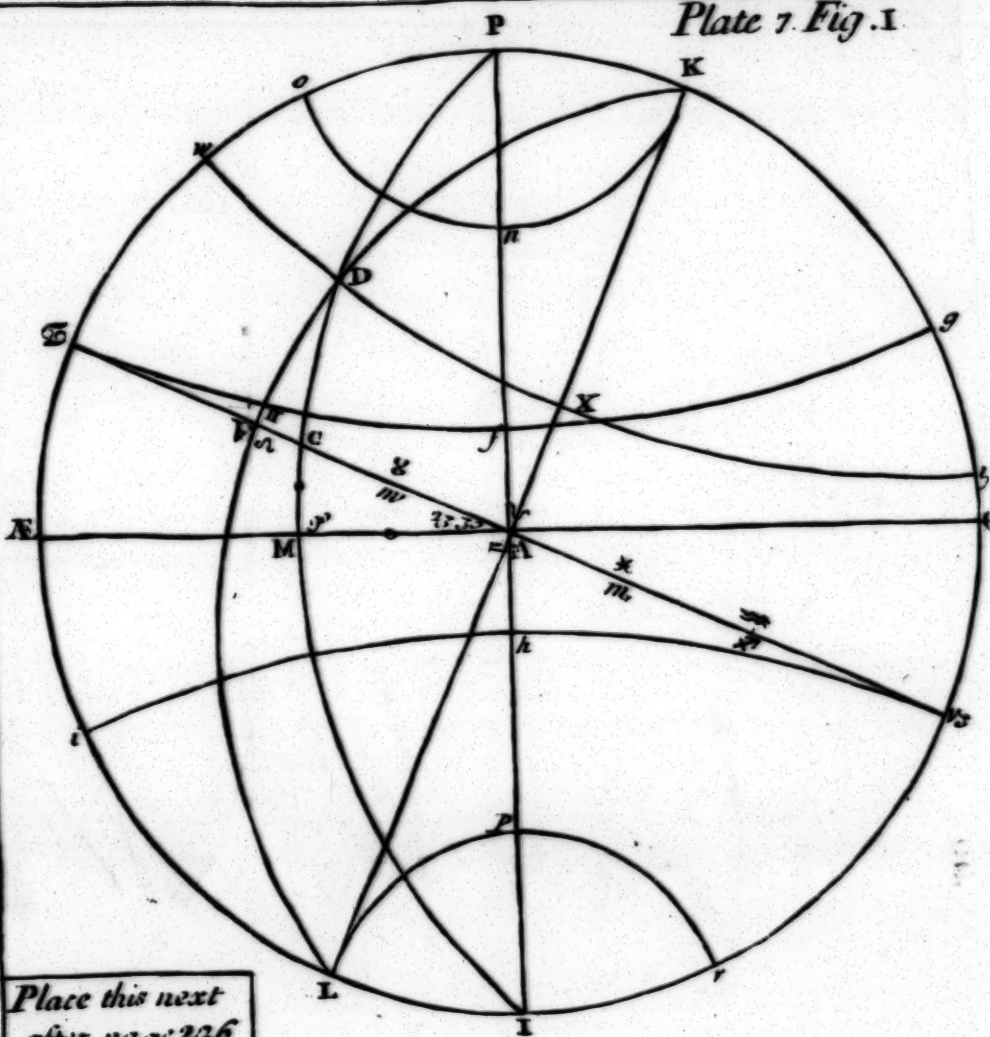


Plate 7. Fig. 1.



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Fixed Stars are solved, I shall at present confine my Discourse, and on which the following Problems are grounded.

In order to a right understanding therefore, I will describe the Circles of the Sphere, and how they are drawn in the *Stereographic Projection*, on the Plane of the Earth's Ecliptic, before I shew how to calculate any of its Requisites.

Note, In the following Description, I make use (for the most part) of the same Letters for the same Things, as before in the *Ptolomaic Projection*, treated of in this Chapter.

The Description of the Circles of the Sphere (as grounded on the antient *Pythagorean*, or *Copernic System* of the World,) are as follow.

1. The Sun illuminateth one half of the Body of the Earth continually; as represented by *Plate 8. Figures 1 and 2*, wherein the Lines *HKS*, or *HLS*, which determine the Illuminate part of the Earth's Diske *A S*, from the obscure *HDS*; the said *HKS*, or *HLS*, is called the Horizon of the Earth's Diske.

2. The Primitive Circle $\gamma \oslash \simeq \gamma \gamma$, is the Earth's Ecliptic; which ever lieth in the Plane of the Ecliptic in the Heavens.

The Poles of the Ecliptic are *K* and *L*; the first is the North Pole of the Ecliptic, on the Earth's Globe, and the latter the South Pole thereof.

The Poles of the Earth's Globe are *P* and *I*; the first its North, and the latter its South Pole: each being 23d. 30m. from its correspondent Pole of the Ecliptic; that is *KP*, equal to *LI*, is equal to 23d. 30m. on the Scale of Half-Tangents, and is called the Line of Direction of the Earth's Axis.

3. The Equinoctial in the Heavens, or the Equator on the Earth, is represented by the Oblique Circles $\gamma Q \simeq$, or $\gamma \mathcal{A} \simeq$, of which *P* and *I* are the Poles, and they are drawn with the Secant of 23d. 30m. according to *Problem 2. Case 2. of Spheric Geometry*, in pages 112 and 113.

4. All Meridians pass through the Poles of the Earth's Globe; as here $\gamma P \simeq$, or $\gamma I \simeq$, are Meridians, and drawn with the Secant of 66d. 30m. the Complement of 23d. 30m. as before.

$\gamma P \simeq$, or $\gamma I \simeq$, is called the First Meridian; and the Meridian $\oslash PK \gamma$, or $\oslash LI \gamma$ is the Earth's Solstitial Colure: for whenever the direct Rays of the Sun run parallel to this Meridian, (and that is, when the Sun appears from the Earth,

to

to be either in $\mathfrak{E}$ and $\mathfrak{V}$; then the longest or shortest Days are made in all Places on the Globe of the Earth.

The Earth's Equinoctial Colure, is $\mathfrak{V} K \infty$, or $\mathfrak{V} L \infty$, for whenever the Central Rays of the Sun run parallel to it, the Days and Nights are equal in all places. Or, according to the *Ptolomaic System*, the Meridian $\mathfrak{V} P \infty$, and $\mathfrak{V} I \infty$, is the Equinoctial Colure, tho' here we call it the first Meridian.

5. Circles of Longitude, pass thro' the Poles of the Ecliptic, and in this Projection, are Right Circles; therefore are streight Lines, as $\mathfrak{V} K \infty$, $\mathfrak{E} K \mathfrak{V}$, $\odot K D$, &c.

Wherefore the Point in the Earth's Periphery. opposite to the Sun, or to a Star, or lying in a streight Line produced from K or L , thro' the Center of the Sun, or any Star, is called the Sun's, or Star's place in the Ecliptic.

These are the Great Circles belonging to this Projection. Now followeth,

The Description of the Parallels or Less Circles.

6. Parallels of Declination, are here parallel to an Oblique Circle; the Equinoctial $\mathfrak{V} Q \infty$, and $\mathfrak{V} \mathfrak{A} \infty$, being such.

The Tropics are two Parallels of Declination, distant from the Equinoctial 23d. 30m. or 66d. 30m. from each Pole of the World; as $\mathfrak{E} f g f \mathfrak{E}$, and $\mathfrak{V} h i h \mathfrak{V}$; the first is the Tropic of Cancer, the latter is the Tropic of Capricorn.

These Tropics are thus drawn; from the Scale of Half Tangents lay on the Solstitial Colure 47d. (the double of 23d. 30m.) from $\mathfrak{V}$ to g , or from $\mathfrak{E}$ to i . Or thus; lay the Half Tangent of 43d. (the Complement of 47d.) from K to g , or from L to i : Then the middle between $\mathfrak{E}$ and g ; or between $\mathfrak{V}$ and i , is the Center of these Tropics.

The Polar Circles, are two Parallels of Declination, distant from the Equinoctial 66d. 30m. or 23d. 30m from each Pole of the World as $K n o n K$, and $L p r p L$; the first is the Artic, the other the Antartic Circle.

They are thus drawn, on the Solstitial Colure, lay the Half Tangent of 47d. (the double of 23d. 30m.) from K to o , or from L to r ; then the middle between K and o , or between L and r , is the Center of those Polar Circles.

7. Parallels of Latitude, with respect to the Heavens, are in this Projection, parallel to the primitive Circle, which here is the Ecliptic: as any Circle drawn on K or L as a Center, is a Parallel of Latitude.

All these Circles are General, as belonging to this Projection

jection, without any Regard to the Latitude of any particular Place, on the Globe of the Earth. The Description of the Meridians or Hour Circles, Azimuths and Parallels of Latitude; also how to draw them, (these being peculiar to a particular Latitude) you shall have in their proper place, as they come in Use in the following Problems.

Problem 1. *The Sun's Place in the Ecliptic given; to find his Distance from the North or South Pole of the Globe; his Right Ascension; and the Angle which the Meridin passing through it makes with the Ecliptic.*

Example. *The Sun's Place being in the beginning of Gemini, or 60 Degrees from the first Point of Aries; I demand his Distance from the Pole, &c.*

1. To do this, lay the Sun's Longitude 60d. on the Primitive Circle, from Υ to $\odot$.

2. Through $\odot$ and P, or $\odot$ and I, draw a great Circle $\odot$ PD, or $\odot$ ID, which is the proper Meridian, to the Place of the Sun.

3. Then, between the proper Meridian, the Ecliptic, and the Solstitial Colure, there is formed a Rectangle Spheric Triangle, having its Legs given; to find the Hypotenuse, and two Angles: That is,

In the Rectangle Spheric Triangle P $\odot$ $\odot$, or I $\odot$ $\odot$, Plate 8. Figures 1 and 2.

1. The Leg $\odot$ $\odot$, is the Complement of the Sun's Longitude from Υ , or his Distance from the Equinoctial, 30d.

2. The Leg $\odot$ P, or $\odot$ I, the Distance of the Pole of the Globe from the Ecliptic; or the Complement of the Distance of the Poles of the Globe and the Ecliptic 66d. 30m.

3. The Hypotenuse P $\odot$, or I $\odot$, the Sun's Distance from the North, or South Pole of the Globe.

4. The Angle $\odot$ P $\odot$, or $\odot$ I $\odot$, the Complement of the Sun's Right Ascension, from the nearest Equinoctial Point.

5. The Angle P $\odot$ $\odot$, or I $\odot$ $\odot$, the Angle of the proper Meridian with the Ecliptic.

1. For the Sun's Distance from the Pole, the Proportion by Chapter 5. Section 4. Problem 5. Case 14. of Spheric Trigonometry Rectangular, in pages 139 and 140, is thus;

As Radius .. S.c. Leg $\odot$ $\odot$:: S.c. Leg $\odot$ P .. S.c. Hypotenuse P $\odot$.
As S. 90d. .. S. 60 deg. :: S. 23d. 30m. .. S. 20d. 12m. the
Reflection.

That is,

As the Radius, is to the Sine of the Sun's Longitude from the Equinoctial; So

So is the Sine of the two Poles Distance, to the Sine Complement of the Sun's Distance from the nearest Pole of the Globe; or to the Sine of P B, or I B, the Reflection, which is equal to the Sun's Declination in the *Ptolomaic System*: In this Case 20d. 12m. North.

2. For the Sun's Right Ascension, the Proportion is;
 As Radius .. S. Leg P☉ :: T.c. Leg ☉☉ .. T. c. Angle ☉P☉.
 As S. 90d. .. S. 66d. 30m. :: T. 60d. .. T. 57d. 49m. Sun's Right Ascension.

That is,

As the Radius, is to the Sine Complement of the two Poles Distance;

So is the Tangent of the Sun's Longitude from the nearest Equinox, to the Tangent of his Right Ascension from the said Equinox.

3. For the Angle of the proper Meridian with the Ecliptic, the Proportion is;

As Radius .. S. Leg ☉☉ :: T. c. Leg ☉P .. T.c. Angle P☉☉
 As S. 90d. .. S. 30d. :: T. 23d. 30m. .. T. 12d. 16m.

Which subtract from _____ 90d. 20m.

The Remainder being _____ 77d. 44m. is the Angle of the Meridian and the Ecliptic.

In the same Rectangle Spheric Triangle, may Problem 2 and 3. of Sect. 2. of this Chap. be resolved, which I pass over.

Problem 2. The Latitude of a Place on the Globe of the Earth, and the Sun's Place in the Ecliptic given; to find his Amplitude, and Ascensional Difference, and consequently his Rising and Setting.

Example. The Latitude 51d. 32m North, Sun's Place 00d. in Gemini given; what's the Sun's Amplitude, and Ascensional Difference?

1. To do this, after you have done what was directed in Problem 1. Then get the Sum and Difference of the Latitude's Complement, and the Distance of the two Poles, that is, the Sum, and Difference of 38d. 28m. and 23d. 30m, the first is 61d. 58m. and the latter is 14d. 58m.

2. Then make K t, or Lt, equal to the Half Tangent of 61d. 58m. and also K m, or L m equal to 14d. 58m. from the same Scale.

3. The middle between m and t, is the Center of the Circle a b c z t d e h m, which is the Parallel of Latitude for 51d. 32m. and in this Projection, it's the Line described by London, as the Earth turns round, and from thence is called the Path of the Vertex.

†

And

And if you conceive the Colures, all the Meridians, the Path of any Vertex, and indeed all the Lines and Circles that are, or shall hereafter be described, as a *fixed Rete*, close investing the Earth, whilst she turns round within it, whose Motion about its Axis being from West to East, then the Sun is said to Rise, when the Vertex passeth that Point in the Path where it cuts the Horizon of the Earth's Disk, which is here at *a*; To culminate or to be on the Meridian, where it crosseth the proper Meridian betwixt him and the Pole, which here is at *z*; and to Set where the Vertex passeth the other Interfection of the Path and Horizon, as here at *h*.

4. Thro' *a* and ☉, draw a great Circle, as also thro' *a* and *P*, so have you two Triangles, on the East-side of the Meridian; to wit, ☉ *Pa*, and *PBa*; in like manner if you draw Great Circles thro' *P* and *h*; and thro' ☉ and *h*; they will form two Triangles on the West, or descending Side of the Meridian: But any one of these four Triangles may serve to answer the Problem, and therefore I take one Triangle at Sun Rising, which may suffice for Sun-Setting; wherein observe,

In the Rectangle Spherical Triangle *PBa*. *Plate 8. Figure 1.*

1. The Leg *PB* the Reflection, or that which is equal to the Sun's Declination, found by Problem 1. in page 239. to be 20d. 12m. North.

2. The Hypotenuse *Pa*, the Complement of the Latitude of the Place, or the Distance of the Pole from the Vertex, in this Example 38d. 28m.

3. The Angle *BaP* the Amplitude, or the Complement of the Sun's Azimuth, from the North in North Latitude; and from the South, in South Latitude; for the Angle *Pa* ☉ is the Azimuth from the North at Sun Rising, and the Angle *BaP* is its Complement, and therefore equal to the Sun's Amplitude.

4. The Angle *BPa*, the Hour from Midnight; that is, the time of the Sun's Rising after, and Setting before 12 at Night.

1. For the Angle *BaP*, the Sun's Amplitude; the Proportion by Chapter 5. Section 4. Problem 1. Case 2. in pages 135 and 136, is;

As S. Hypotenuse *Pa* .. Radius :: S. Leg *BP* .. S. Angle *BaP*.

As S. 38d. 28m. .. S. 90d. :: S. 20d. 12m. .. S. 33d. 43m.

That is,

As the Sine Complement of the Latitude, is to the Radius; So is the Sine of the Reflection, to the Sine of the Sun's Amplitude, 33d. 43m. from the East Northerly, at Sun Rising; and from the West Northealy, at Sun Setting.

Q

2. For

2. For the Angle BPa , the Complement of the Ascensional Difference, the Proportion by the aforesaid Problem 1. Case 1. in page 135, is thus,

As Radius $\dots$ T. c. Hypot. $Pa ::$ T. Leg $BP \dots$ S. c Angle BPa .
 As T. 45d. $\dots$ T. 51d. 32m. $::$ T. 20d. 12m. $\dots$ S. 27d. 35m.
 the Sun's Ascensional Difference, which is equal to 1h. 50m. which is the Time the Sun riseth before 6; and as much after 6, is the Sun's Setting; because the Latitude is North, and the Sun in a Northern Sign; but it's the contrary, when one is North and the other South.

In this Triangle may Problems 4, 5, 6, 7, 8, 9, 10, and 11, of Section 2 of this Chapter be resolved.

Problem 3. The same given as before in Problem 2. to find the Sun's Distance from the Vertex, when due East, or West, and the Time from Noon when he shall be so. *Plate 8. Figure 1.*

Example.

Latitude — 51d. 32m. N. } given; The { Sun's Zenith Distance.
 Sun's Place 00d. 00m. in Π } Time when he is East
 or West Required.

1. To delineate this, after the proper Meridian, and Path of the Vertex, or Parallel of Latitude is drawn, as before in Problem 1 and 2. Then thro' $\odot$ and D, draw a Great Circle, just to touch the Path of the Vertex, on either side of it, as the Oblique Circles $\odot cd$, and $\odot d D$.

2. Through P and c, or P and d, draw a Great Circle, to cut $\odot cd$, $\odot d D$ at Right Angles, which is the Place of the Vertex, when the Sun shall appear due East, or West: And then are formed two Triangles $Pc\odot$, and $Pd\odot$; one when the Sun is East, and the other when he is West; in each the same things are given and required. Therefore observe,

In the Rectangle Spheric Triangle, $Pc\odot$. *Plate 8. Fig. 1.*

1. The Hypotenuse $P\odot$ the Sun's Distance from the Pole, found by Problem 1. to be 69d. 48m. the Complement of the Reflection.

2. The Leg Pc , the Distance of the Pole from the Vertex, or Complement of the Latitude, in this Example 38d. 28m.

3. The Leg $\odot c$, the Sun's Distance from the Vertex, or Complement of his Altitude when East: and the same when West.

4. The Angle $\odot Pc$, the Hour from Noon, when he is, or shall appear to be East, or West.

1. For the Leg $\odot c$, the Sun's Zenith Distance, the Proportion by Chapter 5. Section 4. Problem 1. Case 3. in pages 135, and 136. is,

As

As S. c. Leg P c .. Radius :: S. c. Hypot. $\odot$ P .. S. c. Leg $\odot$ c.
 As S. 51d. 32m. .. S. 90d. :: S. 20d. 12m. .. S. 26d. 10m.
 Sun's Altitude when East, and the same when West.

That is;

As the Sine of the Latitude, is to Radius ;

So is the Sine of the Reflection, to the Sine Complement of the Sun's Zenith Distance ; or his Distance from the Vertex, in this Case 63d. 50m.

2. For the Angle $\odot$ P c, the Hour from Noon, the Proportion is ;

As Radius .. T. Leg P c :: T. c. Hypot. $\odot$ P .. S. c. Angle $\odot$ P c.
 As T. 45d. .. T. 38d. 28m. :: T. 20°. 12' .. S. 17d. 00m. or 1h. 8m.

That is ;

As the Radius, is to the Tangent Complement of the Latitude ;

So is the Tangent of the Reflection, to the Sine Complement of the Hour from Noon, when the Sun is due East, or West ; The Sun is East at 8m. after 7 of the Clock in the Forenoon, and West at 52m. after 4 in the Afternoon.

In this Triangle may Problems 18, 19, 20, 21, 22, and 23, of Section 2. of this Chapter be resolved.

Problem 4. The same given as before in Problem 2. to find the Sun's Distance from the Vertex ; and his Azimuth at the Hour of Six. *Plate 8. Figure 1.*

Example.

The $\left\{ \begin{array}{l} \text{Latitude} - 51\text{d. } 32\text{m. N.} \\ \text{Sun's Place } 00 \quad 00 \text{ in } \pi \end{array} \right\}$ given ; the Sun's $\left\{ \begin{array}{l} \text{Zen. Dist.} \\ \text{Azimuth} \end{array} \right\}$
 at Six of the Clock is required ?

1. To delineate this ; after the proper Meridian, and Path of the Vertex is drawn, as before in Problem 2. Then thro' P, draw a Great Circle, at Right Angles, with the proper Meridian, to cut the Path in b, and in e, and the Horizon of the Earth's Disk in A, where it always intersects the Equator ; as the Oblique Circle A b P e, or A b I e ; which is the Meridian or Hour-Circle of Six, so that b (in the Path) is the Place of the Vertex at Six in the Morning ; and e its Place when Six Afternoon.

2. Therefore thro' $\odot$, and b, or $\odot$, and e, draw a great Circle, and you will form two Right Angled Spheric Triangles b P $\odot$, or e P $\odot$: one of them is sufficient to solve the Question, being equal Triangles. If you take the first at Six in the Morning : it follows,

In the Right Angled Triangle b P $\odot$. *Plate 8. Figure 1.*

1. The Leg P b, the Distance of the Pole from the Vertex ;

Q 2

or

or the Complement of the Latitude, in this Example 38d. 28m

2. the Leg $P\odot$, the Sun's Distance from the Pole, found by Problem 1. to be 69d. 48m. the Complement of the Reflection.

3. The Hypotenuse $b\odot$, the Sun's Distance from the Vertex, or Complement of his Altitude at the Hour of 6.

4. The Angle $Pb\odot$, his Azimuth from the North, in all North Latitudes, and the contrary in South Latitudes: For in what part of the Path soever the Vertex is found, that part of the Hour Circle, intercepted betwixt it and the North Pole of the Globe, is the North part of that Meridian, or Hour Circle; and intercepted betwixt it and the South Pole, is the South part of the Meridian.

5. For the Hypotenuse $b\odot$ the Sun's Distance from the Vertex at the Hour of 6, the Proportion (by Chapter 5. Section 4. Problem 5. Case 14. in pages 139 and 140.) is;

Radius .. S.c. Leg Pb :: S.c. Leg $P\odot$.. S.c. Hyp. $b\odot$.

S. 90d. .. S. 51d. 32m. :: S. 20d. 12m. .. S. 15d. 41m. the Sun's Altitude at 6 in the Morning, or at 6 in the Afternoon.

That is;

As the Radius, is to the Sine of the Latitude;

So is the Sine of the Reflection, to the Sine of the Sun's Altitude, or Complement of his Distance from the Vertex, at the Hour of 6, equal to 74d. 19m.

2. For the Angle $Pb\odot$, his Azimuth at 6, the Proportion is;

As Radius .. S. Leg Pb :: T. c. Leg. $P\odot$.. T. c. Angle $Pb\odot$.

As S. 90d. .. S. 38d. 28m. :: T. 20d. 12m. .. T. 12d. 53m. Sun's Azimuth from the East, at 6 in the Morning; but from the West, at 6 in the Afternoon.

That is;

As the Radius, is to the Sine Complement of the Latitude;

So is the Tangent of the Reflection, to the Tangent Complement of the Sun's Azimuth from the Meridian, at the Hour of 6, equal to 77d. 7m. from the North; that is, almost E. by N. at 6 in the Morning, and near W. by N. at 6 in the Afternoon.

In this Triangle may Problems 12, 13, 14, 15, 16, and 17. of Section 2. of this Chapter be resolved.

Prob. 5. The Sun in the Equinoctial, the Latitude of a Place, and his Altitude given, to find his Azimuth, and Hour of the Day.

Note; The Sun is said to be in the Equinoctial, when he is in the beginning of Υ , or ϖ ; and then he hath no Declination.

Ex. The $\left\{ \begin{array}{l} \text{Latitude } 51^{\circ} 32' \text{ N.} \\ \text{Altitude } 33^{\circ} \text{ AM.} \end{array} \right\}$ given: The $\left\{ \begin{array}{l} \text{Sun's Azimuth} \\ \text{Hour of the Day} \end{array} \right\}$
 Required? To delineate this. Plate 8. Figure 1.

1. The Sun in the Beginning of γ , then the Horizon of the Earth's Disk is $\odot$ PK ω , and the proper Meridian then, is γ P ∞ ; the Sun's rising at London is at m, his Setting at t, &c. The Path of the Vertex being drawn as before in Problem 2.

2. Then (by Problem 9. Case 2. of Spheric Geometry, in page 121.) draw a parallel Circle at 57° distance from Aries, to cut the Path in b, the place of the Vertex of London, when its distance from the Sun is 57° the Complement of the Sun's Altitude.

3. Draw a Meridian through P and b, and a Great Circle through b and γ , the place of the Sun, so will you form the Triangle γ P b, and b P K; either of them will solve the Question:

In the Rectangle Spheric Triangle PKb. Plate 8. Figure 1.

1. The Hypotenuse Pb, the Distance of the Pole from the Path of the Vertex, or Complement of the Latitude, equal to $38^{\circ} 28'$.

2. The Leg Kb, the Sun's Altitude, or the Complement of his Distance from the Vertex, equal to 33° Degrees.

3. The Angle PbK, (the Supplement of the Angle Pb γ , the Sun's Azimuth from the North) is the Sun's Azimuth from the South, in all North Latitudes; but from the North in all South Latitudes.

4. The Angle bPK, the Complement of the Angle bP γ , (the Hour from Noon) is the Hour of the Day from six.

1. For the Angle PbK, the Sun's Azimuth from the Meridian, the Proportion (by Chapter 5. Section 4. Problem 1. Case 1. in page 135) is,

As Radius .. T.c. Hypot. Pb :: T. Leg Kb .. S.c. Angle PbK.

As T. 45° .. T. $51^{\circ} 32'$:: T. 33° .. S. $54^{\circ} 49'$ the Sun's Azimuth from the East: That is:

As Radius, is to the Tangent of the Latitude;

So is the Tangent of the Sun's Altitude (when in the Equinoctial) to the Sine Complement of his Azimuth from the South, that is $35^{\circ} 11'$ South Easterly, or S. E. by S. $\frac{1}{4}$ E. almost;

2. For the Angle PbK, the Hour from 6, the Proportion is

As S. Hypot. P b .. Radius :: S. Leg Kb .. S. Angle b P K.

As S. 38d. 28m. .. S. 90d. :: S. 33d. 00m. .. S. 61d. 06m. equal to 4h. 4m. That is ;

As the Sine Complement of the Latitude is to the Radius ;
So is the Sine of the Sun's Altitude (when in the Equinoctial) to the Sine of the Hour from Six, 61d. 6m. equal to 4h. 4m. which add to 6 makes 4m. after 10 in the Morning ; but had it been in the Afternoon, it must have been subtracted from 6.

In the same Triangle, five Problems more may be resolved, which I leave the Learner to invent.

Problem 6. The Latitude of a Place, the Sun's Place in the Ecliptic, and his observed Distance from the Vertex given ; to find his Azimuth, and Hour of the Day. *Example.*

The	{	Latitude — 51d. 32m. N.	}	given:	{	Sun's Azimuth	}	required		
		Sun's Place 00. 00 in Π				The			{	Hour of the Day
		$\odot$'s Altitude 36. 00 A.M.								

To delineate this, *Plate 8. Figure 1.*

1. Draw a Parallel Circle, 54d. Distance from $\odot$, (the place of the Sun) and where it cuts the Path (of the Vertex) is the place of the Vertex, when it's Distance from the Sun is 54d. or when the Sun's Altitude is 36d. as here it doth at 7 and 5.

2. Thro' 7, and P ; and thro' 7, and $\odot$; draw Great-Circles, which will form the Oblique Spheric Triangle $\odot P 7$; the like may be done thro' 5 and P, and thro' 5 and $\odot$; which will form two other Triangles equal to them.

In the Oblique Spheric Triangle $\odot P 7$. *Plate 8. Figure 1.*

1. The Side P $\odot$, the Distance of the Sun from the Pole, found by Problem 1. to be 69d. 48m. the Complement of the Reflection 20d. 12m. equal to the Sun's Declination.

2. The Side P 7, the Distance of the Pole from the Vertex, or the Complement of the Latitude, equal to 38d. 28m.

3. The Side $\odot 7$, the Sun's Distance from the Vertex, or the Complement of his Altitude in the Forenoon 54d. 00m.

4. The Angle P 7 $\odot$, the Sun's Azimuth from the North.

5. The Angle $\odot P 7$, the Hour of the Day from Noon.

The Angles P 7 $\odot$ and $\odot P 7$ may be found by Chapter 5. Section 5. Prom 11. Case 11. of *Oblique Spheric Trigonometry*, in pages 147 and 148, for there are three Sides given, to find an Angle ; and when wrought you'll find the Angle P 7 $\odot$ 103d. 12m.

12m. the Sun's Azimuth, from the North, or 76d. 48m. from the South Easterly, which makes E. by S. almost.

And the Angle $\odot P 7$ is 57d. 04m. or 3h. 48m. the Hour from Noon, which is 8h. 12m. in the Morning.

But had it been in the Afternoon, then the Hour of the Day is 3h. 48m. and the Azimuth 76d. 48m. South Westerly, or W. by S. almost.

In this Triangle may Problem 1, 2, 3, 4, 5, 6, 7, 8, 9 and 10 of Section 3. of this Chapter be resolved.

Problem 7. The Longitude, and Latitude of a Star given; to find its Right Ascension, and Declination.

Example. *Let the proposed Star be Capella, and supposing its Longitude 18d. 02m. in Π { what is it's { Right Ascension?
Latitude 22d. 52m. North { Declination?*

To delineate this Problem. *Plate 8. Figure 1.*

1. Lay off the Star's Longitude 78d. 02m. (from the Chords) on the Primitive Circle, from γ to y , and draw the Circle of Longitude $K y$.

2. From the Half Tangents lay 67d. 08m. (the Complement of the Star's Latitude, or it's Distance from the nearest Pole of the Ecliptic) on the Circle of Longitude from K to $*$.

3. Thro' P , and $*$, draw a Great Circle, which is a Meridian passing over the Star, and it's done.

In the Oblique Spheric Triangle $K P *$, *Plate 8. Figure 1.* Observe :

1. The Side PK , the Distance of the two Poles, or Line of Direction of the Earth's Axis equal to 23d. 30m.

2. The Side $K *$, the Star's Distance from the Pole of the Ecliptic, or the Complement of its Latitude, equal to 67 deg. 08 min.

3. The Angle $PK *$, the Star's Longitude from the Solstitial Colure, in this Problem 11d. 58m. from $\odot$.

4. The Angle $K P *$, the Star's Right Ascension from the opposite Point of the same Colure.

5. The Side $P *$, the Star's Distance from the Pole of the Globe, or Complement of his Declination.

So that here are two Sides, and an Angle between them given; to find an Angle, and the third Side; which is performed by Chapter 5. Section 5. Problem 9. Cases 7 and 8. of *Oblique Spheric Trigonometry*, in pages 144 and 145, and being the same as Problem 11. of Section 3. of this Chapter, in page 234. I leave it to the Learner's Working.

Problem 8. The Latitude of a place, the Sun's place in the Ecliptic, and the time of the Day given; to find what point of the Ecliptic culminates the highest Point in the Ecliptic, (called the *Nonagesima Degree*, or 90th Degree of the *Ecliptic*) the Distance of each of these from the *Vertex*, and the *Parallactic Angle* or Angle which the Vertical Circle makes with the Ecliptic.

It's usual to find these things in the Calculation of Eclipses, and the Moon's passing over Fixed Stars; which in the *Ptolemaic Projection*, are with much Difficulty shewn, but in this most readily and easily represented.

Example.

Latitude	51d. 32m. N.	} given; the	} Point Culminating Nonagesima Degree Vert. Dist. of each
Sun's place	ood. oom. in Π		
Hour	9h. oc.m. AM.		

required: To delineate this. *Plate 8. Figure 1.*

1. The Sun's place, proper Meridian, and Path of the Vertex, being drawn as before, draw an Hour Circle, or Meridian thro' P 45d. (the Distance of the given Hour) from the proper Meridian, as P 9, to cut the Path of the Vertex in 9, and the Earth's Ecliptic in C, and in F.

2. Thro' $\odot$ 9, and D, draw a Verticle Circle; and thro' K, and 9, draw a Circle of Longitude, to cut the Primitive Circle in N, and it's done. For,

1. C is the point of the Ecliptic Culminating, or in the Meridian of the place, at the given time.

2. N is the *Nonagesima Degree*, or the highest point of the Ecliptic at the same time.

3. C9, and N9, are their respective Distances, from *London's* Vertex at that time.

4. The Angle N $\odot$ 9, is the *Parallactic Angle*, or Angle which the Vertical Circle makes with the Ecliptic at the the same time.

In the Rectangle Spheric Triangle P $\odot$ C.

1. The Angle CP $\odot$, is the Complement of the Right Ascension of the Mid-heaven, or point of the Ecliptic in the Meridian of the place at the proposed Time, being the Time from Noon, (when Afternoon added to the Sun's Right Ascension, found by Problem 1. But when the proposed Time is in the Forenoon it must be subtracted) in this Case is 77d. 11m. the Complement of 12d. 49m. found by subtracting (the Time) 45d from 57m. 49m. the Sun's Right Ascension.

2. The Leg P $\odot$, is the Complement of the Distance of the Poles of the Globe, and Ecliptic, equal to 66d. 30m.

3. The

3. The Leg C $\ominus$, the Complement of $\vee$ C, is the Longitude of the Mid-heaven, or the Point of the Ecliptic Culminating in the Meridian, at the proposed Time.

4. The Hypotenuse CP, the Distance of the Mid-heaven from the next or nearest Pole of the Globe, at the same Time.

1. For the Leg C $\ominus$, the Point Culminating, the Proportion by Chapter 5. Section 4. Problem 3. Case 7. in pages 137 and 138, is;

As Radius .. S. Leg P $\ominus$:: T. Angle CP $\ominus$.. T. Leg C $\ominus$.

As S. 90d. .. S. 66d. 30m. :: T. 77d. 11m. .. T. 76d. 02m. whose Complement 13d. 58m. is $\vee$ C; therefore the Longitude of the Mid-heaven is 13d. 58m. in $\vee$.

2. For the Hypotenuse CP the Proportion is;

Radius .. S. c. Angle CP $\ominus$:: T. c. Leg P $\ominus$.. T. c. Hypotenuse CP.

S. 90d. .. S. 12d. 48m. :: T. 23d. 30m. .. T. 5d. 30m. whose Complement 84d. 30m. is PC, from which take away P $\ominus$ the Distance of the Pole from the Vertex 38d. 28m. the Remainder is $\ominus$ C, the Distance of the Mid-heaven from the Vertex 46d. 2m. in the Oblique Spheric Triangle P $\ominus$ K.

1. The Side PK, the Distance of the two Poles 23d. 30m.

2. The Side P $\ominus$, the Complement of the Latitude of the Place, 38d. 28m.

3. The Angle KP $\ominus$, the Difference of the Right Ascension of the Mid-heaven, and the first Point of *Capricorn*, equal to 102d. 48m. found by subtracting 270 Degrees, out of (12d. 48m. added to 360 Degrees, which is) 372d. 48m.

4. The Angle PK $\ominus$, the Longitude of the *Nonagesima* from the first Point of $\ominus$.

5. The Side K $\ominus$, the Complement of the *Nonagesima's* Distance from the Vertex.

First, for the Angle PK $\ominus$, the Proportion by Chapter 5. Section 5. Problem 9. Case 7. in pages 144 and 145, is thus,

1. As the Sine of half the Sum of the Sides P $\ominus$, and PK, is to the Sine of half their Difference;

So is the Tangent Complement of half the Angle KP $\ominus$, to the Tangent of half the Difference of the Angles PK $\ominus$, and P $\ominus$ K; Then,

2. As the Sine Complement of half the Sum of the Sides P $\ominus$, and PK, is to the Sine Complement of half their Difference;

So is the Tangent Complement of half the Angle KP $\ominus$, to the Tangent of half the Sum of the Angles PK $\ominus$, and P $\ominus$ K.

That

That is,

	d. m.	d. m.	d. m.	d. m.	
1. As S.	30.59	.. S.	07.29	:: T.	38.36
2. As S.	59.01	.. S.	82.31	:: T.	38.36
				.. T.	42.43

And, Which being added, is the Angle P K 9 ————— 54.08 equal to $\odot$ N, which subtract from ————— 90.00

Remainder is the Long. of the *Nonagesima* — 35 52 from *Aries*.

Therefore the Place of the *Nonagesima* — 5d. 52m. in *Taurus*.

Secondly, For the Side K 9, the Proportion is thus;

As S. Angle P K 9 .. S. Side P 9 :: S. Angle K P 9 .. S. Side K 9.
 As S. 54d. 08m. .. S. 38d. 28m. :: S. 102d. 48m. .. S. 48d. 28m.
 the Distance of the Vertex from the Pole of the Ecliptic, equal to which is the Altitude of the *Nonagesima*, whose Complement 41d. 32m. is N 9, its Distance from the Vertex.

Again, in the Rectangle Spheric Triangle $\odot$ N 9.

1. The Leg $\odot$ N, the Sun's Distance from the *Nonagesima*, in this Case 24d. 08m. found by subtracting $\vee$ N 35d. 52m. from $\vee \odot$ 60d. 00m.

2. The Leg N 9, the Distance of the *Nonagesima* from the Vertex; found as above to be 41d. 32m.

3. The Hypotenuse $\odot$ 9, the Sun's Distance from the Vertex.

4. The Angle N $\odot$ 9, made between the Vertical Circle and the Ecliptic, is the Parallaxic Angle; to find which, the Proportion (by Chapter 5. Section 4. Problem 5. Case 13. in pages 139, and 140) is,

As Radius .. S. Leg $\odot$ N :: T. c. Leg N 9 .. T. c. Angle N $\odot$ 9.
 As S. 90d. .. S. 24d. 08m. :: T. 48d. 28m. .. T. 24d. 47m. whose Complement 65d. 13m. is the Parallaxic Angle N $\odot$ 9 at the Sun.

And for the Hypotenuse $\odot$ 9, the Sun's Distance from the Vertex, the Proportion is,

As Radius .. S. c. Leg $\odot$ N :: S. c. Leg N 9 .. S. c. Hypot. $\odot$ 9.
 As S. 90d. .. S. 65d. 52m. :: S. 48d. 28m. .. S. 43d. 05m. whose Complement 46d. 55m. is the Sun's Distance from the Vertex, at the proposed Time.

But to calculate the Parallaxic Angle at the Moon, or at a Star, that has Latitude from the Ecliptic, it will require a little more Labour, as in the next Problem.

Problem 9. The Latitude of a Place, Sun's Place in the Ecliptic, Time of the Day or Night, and the Longitude, and Latitude of the Moon, or of a Star, being given; to find the Parallaxic

lactic Angle at the Moon, or at the Star; and it's Distance from the Vertex.

Example.

Latitude — 51d. 32m. N.	} given: The {	Parallact. Ang and Vertical Dist. }	} required
Sun's Place 05d. 00m. in Π			
Hour — 9h. A.M.			
* Capella Lon. 18.02 in Π			
Its Latitude — 22.52 N.			

To delineate this, *Plate 8. Figure 1.*

1. Lay off the Sun's Longitude, and draw the proper Meridian, Path of the Vertex, the Hour Circle according to the proposed Time, the Vertical Circle, and Circle of Longitude, in all respects as before in Problem 8.

2. Lay off the Star's Longitude and Latitude, as before in Problem 7. then is N the Place of the *Nonagesima*, 9 the Vertex, and * the Star's Place.

3. Through * and 9, draw a great Circle, and it's done.

For * 9, is the Star's Distance from the Vertex; and the Angle K * 9, the Complement of the Parallaxic Angle required: In order to the finding them by Calculation.

First, Find the Place of the *Nonagesima* by Problem 8, which is in *Taurus* 5d. 52m. equal to $\vee N$ 35d. 52m.

Secondly, The *Nonagesima*'s Distance from the Vertex, which is N 9, is equal to 41d. 32m.

Then in the Oblique Spheric Triangle * K 9.

1. The Side K*, the Star's Distance from the next Pole of the Ecliptic, or the Complement of it's Latitude, equal to 67d. 08m.

2. The Side K 9, the Distance of the Vertex from the said Pole, which is equal to the Altitude of the *Nonagesima*, 48d. 28m. found by Problem 8. in page 250.

3. The Angle * K 9, the Difference of the Longitude of the given Star, and the *Nonagesima*, equal to 42d. 10m. and is the Difference of $\vee N$ 35d. 52m. and $\vee y$ 78d. 02m.

4. The Angle K * 9, the Complement of the Parallaxic Angle, at the given Star.

5. The Side * 9, the Star's Distance from the Vertex.

First, To find the Angle K * 9, the Proportion by Chap. 5. Section 5. Problem 9. Case 7. in pages 144 and 145, is,

1. As the Sine of half the Sum of the Sides K *, and K 9; is to the Sine of half their Difference: So is the Tangent Complement

ment of half the Angle $\star K_9$; to the Tangent of half the Difference of the Angles $K_9\star$, and $K\star_9$. Then,

2. As the Sine Complement of half the Sum of the Sides $K\star$, and K_9 , is to the Sine Complement of half their Difference;

So is the Tangent Complement of half the Angle $\star K_9$; to the Tangent of half the Sum of the Angles $K_9\star$ and $K\star_9$.

That is;

d. m.	d. m.	d. m.	d. m.	
1. As S. 57.48	.. S. 9.20	:: T. 68.55	.. T. 26.26.	And,
2. As S. 32.12	.. S. 80.40	:: T. 68.55	.. T. 78.14.	They being

subtracted, gives the Angle $K\star_9$ ——— 51.48. whose Complement 38d. 21m. is the Parallaetic Angle at *Capella*.

Secondly, To find $\star_9$, the Vertical Distance, the Proportion is As S. Angle $K\star_9$.. S. Side K_9 : : S. Angle $\star K_9$.. S. Side $\star_9$.
As S 51d 48m. .. S. 48d. 28m. : : S. 42d. 10m. .. S. 39d. 45m.

The Distance of the Star *Capella* from the Vertex at the Time proposed.

I might proceed to other Problems, and shew how they are formed and represented in this Projection, but I leave that for the Learner's Exercise.

I pass by what (at first) I intended, which was the Orthographic Projection of the Globe; whereby the Moon's Appulses to the Sun or Stars, and all the Appearances of an Eclipse, Occultation or Transit, are represented to the Eye; useful to find the Longitude of Places, on the Globe of the Earth, a thing much talk'd of, greatly desired, and by some pretended to be found though not made known, and I believe will never be made practicable at Sea. However, by this Hypothesis, with accurate Tables of the Moon and Stars Places, and a Way of taking an Altitude or an Angle at Sea unto two or three Minutes; it might be made useful to observe for Longitude, and therefore it's highly worthy of our Seamen's Study, but without such Altitudes, it will not find the Longitude unto two or three Degrees: And for Encouragement hereunto the Government hath by an Act of Parliament promised Twenty Thousand Pounds, and for the Learner's Help herein, I am ready to communicate all the Assistance I can elsewhere; for here's now no Place for it, lest the Book (swelling too big) should be deform'd.

And note; These two Figures in Plate the 8th, are a Representation of the two Hemispheres before described in Chapter 6. Section 4. in pages 180 and 181. So that in those larger, all these Problems might be more exactly formed, and their

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Requisites more truly measured; and if the particular Circles belonging to any Problem, such as the proper Meridian, other Meridians, Hour Circles, Path of the Vertex, Circles of Longitude, and Verticle Circles, to a particular Time, &c. were drawn with Black Lead, they might be wiped out at Pleasure, and the Hemispheres no way damnified.

And when any Circle happens so large as not easily to be drawn, or struck with Compasses, it may be done with a Bow of the Length of the Diameter of the Hemispheres; such being well made with 3 Screws, by their turning, will rise up to several Circles, that may (in the Projection) be required to be drawn.

CHAPTER X. *Of the Variation of the Compass, what it is, how to find it, and how to rectify the Compass thereby.*

Definition 1. *Variation of the Compass*, is an Arch of the Horizon contained between the Meridian of the Place, and the Magnetic Meridian; it's either East, or West, and never exceeds 90 Degrees.

2. *East Variation*, is when the North Point of the Magnetic Meridian lieth Eastward of the North Point of the Meridian of the Place; but if to the Westward, then is it called West Variation.

3. *Magnetic Meridian*, is a great Circle passing thro', or by the Magnetic Poles; to which Meridian the Compass (if not otherwise hindered) hath respect.

4. *Magnetic Poles*, are two moving opposite Points, making their Revolution about the Poles of the World (as Mr. Bond said in his *Longitude found*, page 7.) in 600 Years in a Circle about 8d. 30m. distant therefrom; and their Motion (as he saith) is the Cause of the Variation of the Compass.

5. *The Variation of the Compass* is found by an Amplitude, or an Azimuth.

6. To find the *Variation of the Compass* by an Amplitude, you must have the Latitude of the Place, the Declination, and Magnetic Amplitude of the Sun, given.

7. *Magnetic Amplitude*, is an Arch of the Horizon, contained between the Sun (at his Rising, or Setting) and the East or West Points of the Compass steered by: Or, it's the apparent Rising, or Setting of the Sun from the East, or West points of the said Compass, and is found by observing the Sun, either at his Rising, or Setting, by an Amplitude Compass.

8. *Amplitude*

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8. *Amplitude*, is an Arch of the Horizon, contained between the Sun and the East, or West Points of the Horizon; and is found by Chapter 9. Section 2. Problem 4. in pages 216 and 217, which I call the True Amplitude.

9. If the two foregoing Amplitudes agree, that is, the Magnetic and True Amplitudes (which is seldom) there is no Variation; but if they differ, their Difference rightly counted is the Variation.

Note here; If you always count both Amplitudes from the North; then this is a General Rule.

At Sun Rising { True ——— } Amplitude greatest, the
 { Magnetic

Variation is { East } But at Sun Setting it's { West.
 { West } { East.

Example 1. At Sun Rising, suppose the True Amplitude be East 33 Degrees Northerly, and the Magnetic Amplitude be East 17 Degrees Northerly; then counting both these from the North, the True Amplitude will be North 57 Degrees Easterly, and the Magnetic North 73 Degrees Easterly; the Magnetic is the greatest, and the Difference is 16 Degrees, which is the Variation Westerly: If this had been at Sun-setting, the Variation would then be Easterly.

Example 2. At Sun-setting let the true Amplitude be West 16 Degree Northerly, and the Magnetic Amplitude West 9 Degrees Southerly, both counted from the North, the True Amplitude is North 74 Degrees Westerly, and the Magnetic is 99 Degrees from the North, and is the greatest; their Difference is 25 Degrees, which is the Variation Easterly.

Or thus, in these two Rules.

1. The Amplitudes both North, or both South; their Difference is the Variation. But one North, the other South, their Sum is the Variation.

2. Both the Amplitudes (before your Face) from you, if the True Amplitude be to the Right-hand of the Magnetic, the Variation is East; but when it's to the Left-hand, then the Variation is West.

These Rules will be exemplified in the Problem and Examples following.

Problem 1. The Latitude of the Place, the Sun's Declination, and Magnetic Amplitude given; to find the Variation of the Compass.

Plate 3 Fig 1

Fig 2

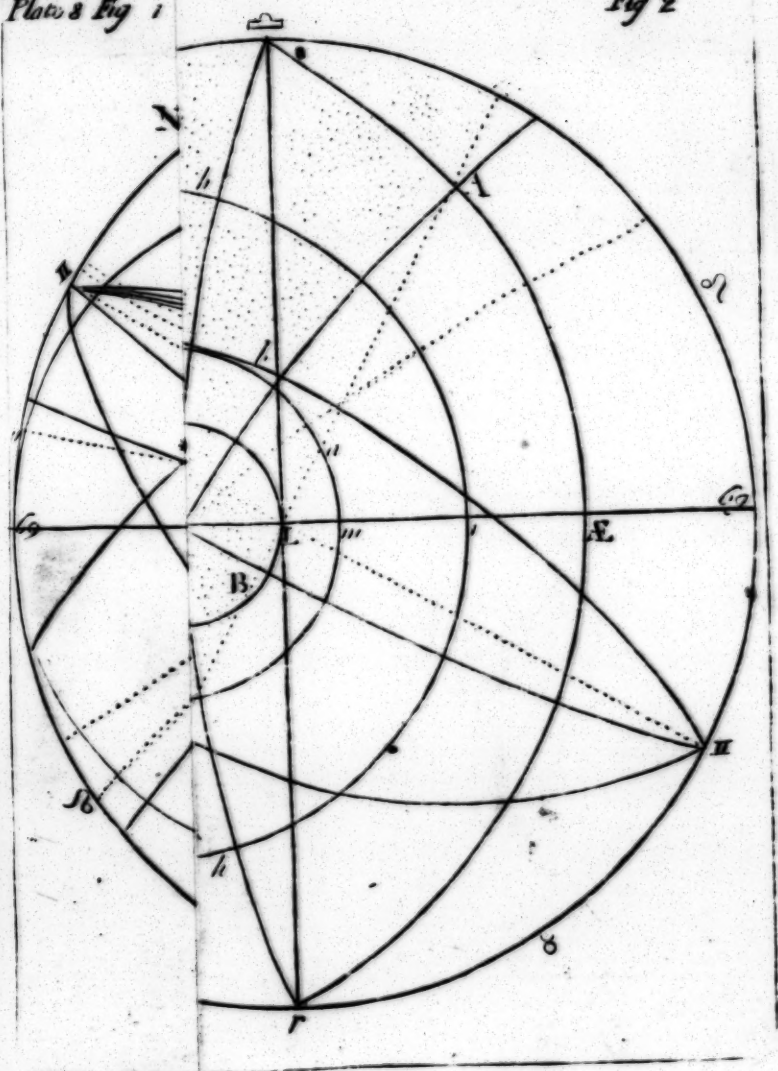


Plate 8 Fig 1

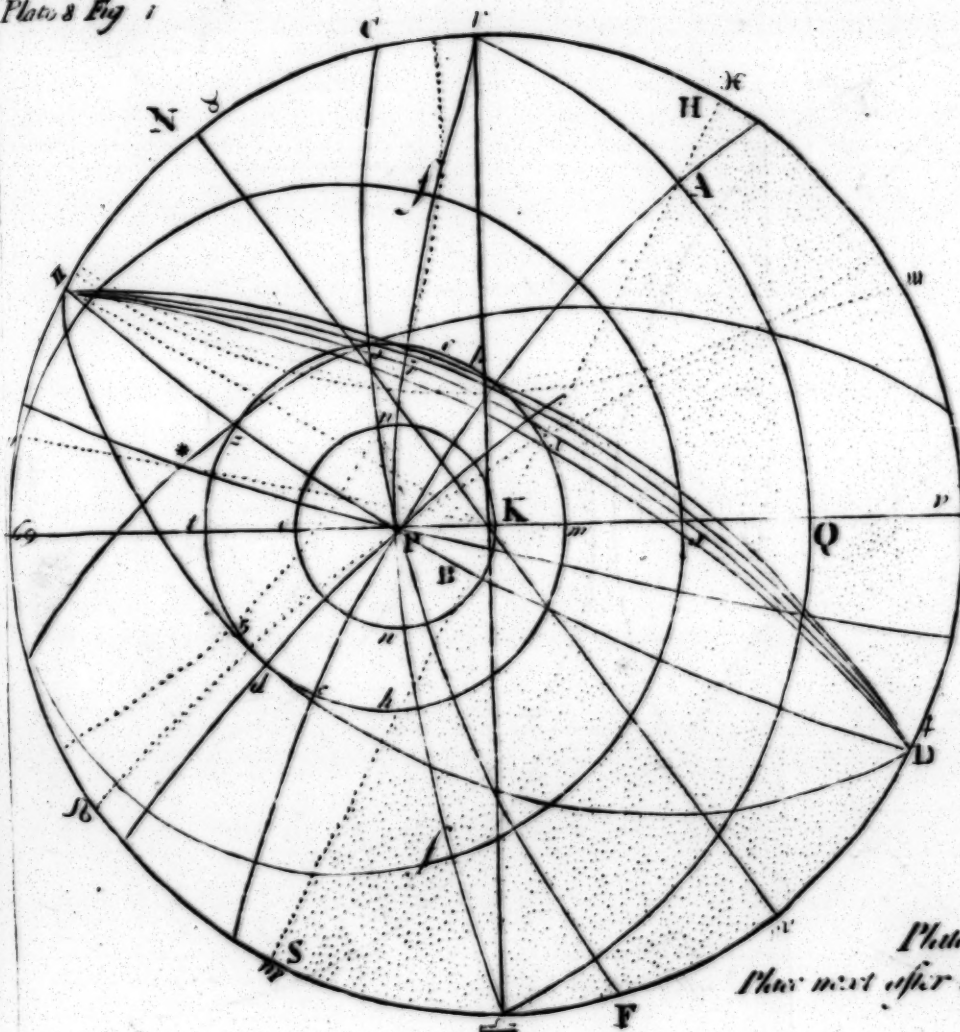
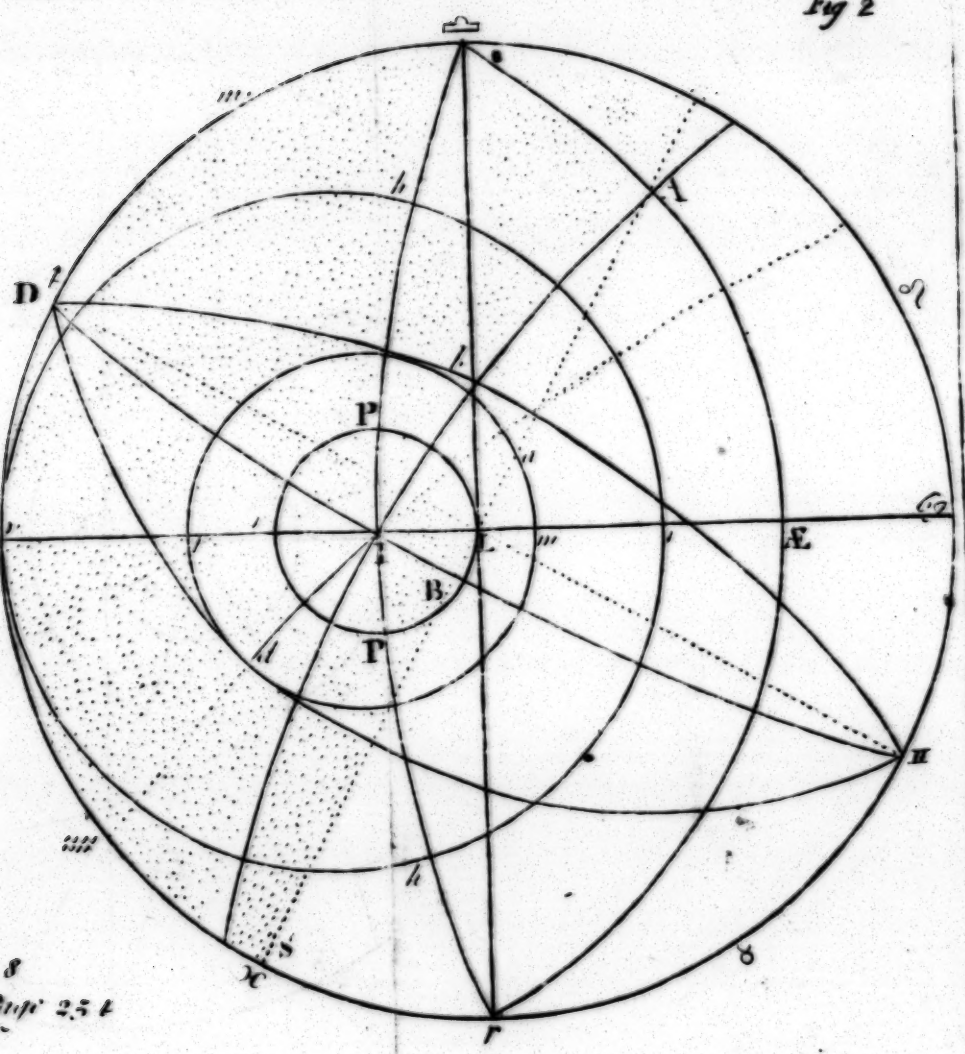


Plate 8
 Plate next after Page 25

Fig 2



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Example.

The { Latitude ——— 51d. 32m. } North given;
 { Sun's Declination ——— 20 10 } The Variation is
 { ☉'s Magnetic Amplitude 17 10 A.M. } Required?

To delineate this Problem Orthographically. Plate 9. Figure 1.

1. Describe a Circle and quarter it; on whose Diameters place W. N. E. and S. (but always) N. at the Right Hand, and A at the Center of the Circle.

2. Lay the Lat. if { North } from { N } upwards to { P }
 { South } { S } { I }

and the same way from W to $\mathcal{A}$ E, and draw the Axis P A I, and the Equinoctial $\mathcal{A}$ E A Q.

3. By laying the Chords of the Sun's Declination on the Primitive Circle from the Equinoctial, draw the Parallel of Declination parallel to it; as the freight Line d C e, to cut the Horizon S A N, in C, the place of the Sun's Rising, or Setting.

4. Measure AC on the Line of Sines, is the Sun's true Amplitude North, if the Declination be North: but South when the Declination is South.

5. Draw the Line CF, parallel to WAE (downward when it's AM, but upward if it be PM) to cut the Primitive Circle in F.

6. Lay the Magnetic Ampl. if { A. M. } from { E } to
 { P. M. } { W }
 G, on the Primitive Circle, towards N if it be North; but towards S when it is South.

7. The Distance from G to N, laid (the same way) from F to False North, (which now is the North Point of the Compass,) and it's done.

For the Distance from N to false North, measured on the Scale of Chords, is the Variation of the Compass.

To find the Sun's true Amplitude, the Proportion by Chap. 9. Section 2. Problem 4. in page 217.

As S. c. Latitude .. Radius :: S. ☉ Declinat. .. S. ☉ Amplitude.
 As S. 38d. 28m. .. S. 90d. :: S. 20d. 10m. N. .. S. 33d. 40m. N.
 d. m. d. m.

Sun's true Ample. EF. 33.40 E.N. or NF 56.20 North Easterly.

Sun's Magnetic F G 17.10 E.N. or NG 72.50 North Easterly.

Subtract gives the Variation ——— 16.30 West.

Example 2. d. m.

The { Latitude ——— 40.50 } North }
 { Sun's Declination 10.19 } given; Variat. Req.
 { ☉ Magnet. Ampl. 15.10 South AM. }

Ans.

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Answer. The Sun's true Amplitude is 13d. 42m. East North-erly, found by the foresaid Proportion, by which the Variation is found, as follows ;

d. m. d. m.
 ☉ True Amplitude EF 13.42 EN. or NF 76 18 N. Easterly

☉ Magnetic Amp. EG 15.10 ES. or NG 105 10 N. Easterly

Subtract, gives the Variation ——— 28 52 West.

The following Examples are for the Learner's Exercise, and are wrought by the foresaid Directions and Rules.

Example 3. d. m.

The { Latitude ——— 13 10 North }
 { Sun's Declination 15 40 South } given ; Varia. required?
 ☉ Magnet. Amplit. 9 12 S. PM }

According to the foresaid Rules, it's as follows:

d. m. d. m.
 ☉ True Amplit. WF 16 06 WS. or NF 106 06 N. Westerly

☉ Magnetic — WG 9 12 WS. or NG 99 12 N. Westerly

Subtract gives the Variation ——— 6 54 West.

Example 4. d. m.

The { Latitude ——— 50 40 — }
 { Sun's Declination 19 50 — } South given, Variat. req.
 ☉ Magnet. Amplit. 5 15 P.M. }

Answer. The Variation is 27d 7m. West.

Example 5. d. m.

The { Latitude ——— 21 30 — } North } given ; Va-
 { Sun's Declination 17 56 — } riat. required
 ☉ Magnet. Amplit. 10 19 South P. M. }

Answer. The Variation is 29d. 39m. East.

Example 6. d. m.

The { Latitude ——— 25 30 South }
 { Sun's Declination 18 12 North } given ; Variat. Req.
 ☉ Magnet. Amplit. 9 50 S. AM. }

Answer. The Variation is 30d. 6m. West.

Secondly, To find the Variation of the Compass by an Azi-muth, observe these following Definitions.

1. *Magnetic. Azimuth,* is an Arch of the Horizon contained between the Sun's Azimuth Circle, and the Magnetic Meridian; Or it's the apparent Distance of the Sun from the North, or South Point of the Compass; and is found by observing the Sun by the Azimuth Compass, either in the Forenoon or Afternoon, when he is about 5, 10 or 15 Degrees high.

2. *Azimuth,* is an Arch of the Horizon contained between the

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the Azimuth Circle passing over the Sun, and the Meridian of the Place, which I call the True Azimuth, and is found by *Chapter 9. Section 5. Problem 1. of Astronomy*, in *pages 229 and 230.*

3. If the said Azimuths agree; that is, if the True Azimuth, and Magnetic Azimuth agree, there is no Variation; but if they differ, their Difference is the Variation; which rightly, to account, observe this General Rule.

Reckon always both Azimuths (like as I said for Amplitude in page 254.) from the North.

In the Forenoon the $\left\{ \begin{array}{l} \text{True —} \\ \text{Magnetic} \end{array} \right\}$ Azimuth greatest, the

Variation is $\left\{ \begin{array}{l} \text{East} \\ \text{West} \end{array} \right\}$ But in the Afternoon it's $\left\{ \begin{array}{l} \text{West.} \\ \text{East.} \end{array} \right\}$

Example 1. In the Forenoon, suppose the Sun's true Azimuth from the North to be 80 Degrees, and the Magnetic Azimuth at the same time to be 101 Degrees, the Magnetic is the greatest, and their Difference 21 Degrees is the Variation of the Compass Westerly; but Easterly, had it been in the Afternoon.

Example 2. In the Afternoon let the Sun's true Azimuth be 115 Degrees, and the Magnetic Azimuth 101 Degrees, their Difference 14 Degrees is the Variation Westerly; but Easterly, had it been in the Forenoon.

Or thus, by the following Rules.

1. Always count both Azimuths from the North, in North Latitude; but from the South in South Latitude.

2. The less Azimuth subtract from the greater, gives the Variation.

3. Placing both the Azimuths (before your Face) from you, if the true Azimuth be to the Right-hand of the Magnetic, the Variation is East. But if to the Left-hand the Variation is West.

These Rules will appear plain in working the *Examples* of the next *Problem*:

Problem 2. The Latitude of the Place, the Sun's-Altitude, Sun's Declination, and his Magnetic Azimuth given, to find the Variation of the Compass?

Example 1.

d. m.

{	The { Sun's	Latitude —	51 32 North	}	given : Variation required ?
		Altitude —	11 30 A.M.		
		Declination —	15 10 North		
		Magn. Azim.	101 10 North		

To delineate the *Problem Orthographically*, *Plate 9. Fig. 2.*

R

1. De.

1. Describe a Circle, quarter it, lay off the Latitude, draw the Equinoctial, Axis, and Parallel of Declination, in all respects as before directed, (in *Problem 1. Page 255.*)

2. By laying the Chord of the Sun's Altitude on the Primitive Circle from the Horizon SAN , draw the Parallel of Altitude parallel to it, as is the Line aCb , to cut the Parallel of the Sun's Declination dCe in C ; the Place of the Sun at that time.

3. Draw Ch parallel to WAE , downward when it's A.M. but upward's if it be P.M. till it meet in an Arch (made with half the Parallel of Altitude) from the Center (of the Primitive Circle) A , and cutteth the said Arch in h .

4. By A and h draw a Line, to cut the Primitive Circle in F ; then NF , or SF , measured on the Scale of Chords sheweth the Sun's true Azimuth.

5. Lay the Magnetic Azimuth (if $\left\{ \begin{array}{l} \text{North} \\ \text{South} \end{array} \right\}$ Latitude) from $\left\{ \begin{array}{l} N. \\ S. \end{array} \right\}$ towards $\left\{ \begin{array}{l} E. \\ W. \end{array} \right\}$ (when it is $\left\{ \begin{array}{l} A.M. \\ P.M. \end{array} \right\}$) to G on the Primitive Cir. But if $\left\{ \begin{array}{l} P.M. \\ A.M. \end{array} \right\}$ towards $\left\{ \begin{array}{l} W \\ E \end{array} \right\}$ to the said G .

6. The Distance from G to N , laid (the same Way) from F to False North, which is now the North Point of the Compass, and it's done.

For the Distance from N to False North, measured on the Scale of Chords, is the Variation of the Compass required.

Then to find the Sun's true Azimuth, the Proportion by *Chapter 9. Section 3. Problem 1.* in pages 229 and 230. is thus.

	d.m.	d.m.	d.m.
Latitude	90.00	90.00	90.00
Latitude	51.32	N. $\odot$ Alt. 11.30	A.M. $\odot$ Decl. 15.10
Comp. Lat.	38.28	Com. $\odot$ At. 78.30	$\odot$ dist. fr. pole 74.50
Comp. $\odot$ Altitude	78.30	Radius S.c. .. Lat. :: S.c. $\odot$ At. ..	24th Sine
$\odot$'s dist. fr. pole	74.50		
Sum is	191.48	d.m.	d.m.
The half Sum is	95.54	S. 90d. .. S. 38.28. :: S. 78.30 .. S. 37.33.	
The Remainder is	21.04	4th Sine .. S. half Sum :: S. Rem. ..	5th Sine
	d.m.	S. 37.33 .. S. 95.54 :: S. 21.04 .. S. 35.55.	

And against Sine 35.55, on the Verfed Sines, is the Sun's True Azimuth

Sun's Magnetic Azimuth

Subtract giveth the Variation

And

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And for the Learner's Practice, take these following Examples, whose answers are found by the Rules foregoing.

Example 2.

The { Latitude ———— 13 10 North }
 { Sun's { Altitude ———— 17 50 A. M. } given : Varia-
 { Declination ———— 16 59 South. } tion re-
 { Magnet. Azim. 90 10 North } quired ?

d. m. d. m. d. m.
 90.00 90.00 90.00

Latitude 13.10 N. ☉'s Altit. 17.50 A.M. ☉'s Decl. 16.50 S.

Comp. Latitude 76.50 Comp. Alt. 72.10 ☉'s dist. fr. pole 100.59

Comp. ☉ Altit 72.10 Radius .. S.c. Lat. :: S.c. ☉'s Alt. .. a 4th Sine

☉'s dist. fr. p 106.59 d. m. d. m. d. m.

Sum is ——— 255.59 S. 90d. :: S. 76.50 :: S. 72.10 .. S. 67.58

The ½ Sum 127.59 Then again,

The Remain. is 21.00 4th Sine .. S. 1 Sum :: S. Rem. .. a 5th Sine

S. 67.48 .. S. 127.59 :: S. 21.00 .. S. 17.45.

And against Sines 17d. 45m. on the versed Sines, is the

☉'s True Azimuth ———— 113d. 00m. North Easterly

☉'s Magnetic Azimuth ———— 90d. 10m. North Easterly

Subtract giveth the Variation 22d. 50m. East.

Example 3.

The { Latitude ———— 28.40 North }
 { Sun's { Altitude ———— 20.19 P. M. } given : Varia-
 { Declination ———— 19.12 South } tion required ?
 { Magnet. AZ. — 129.50 North }

Answer. By the foresaid Directions, the

☉'s True Azimuth ———— 127d. 02m. N. Westerly.

☉'s Magnetic Azimuth ———— 129d. 50m. N. Westerly.

Subtract giveth the Variation ———— 2d. 48m. East.

Example

The { Latitude ———— 50 40 South }
 { Sun's { Altitude ———— 25 10 P. M. } given : Variation
 { Declination ———— 23 30 South } required ?
 { Mag. Azim. 100 20 South }

Answer. The Variation is 17d. 20m. West.

Example 5.

The { Latitude ———— 23 10 South }
 { Sun's { Altitude ———— 10 15 A. M. } given : Varia-
 { Declination ———— 23 30 North } tion required ?
 { Magn. Azim. — 102 40 South }

Answer. The Variation is 18d. 32m. West.

Example 6. d. m.

The { Latitude ————— 37.45 South
 { Altitude ————— 18.20 P. M.
 { Sun's Declination — 20.15 North
 { Magnet. Azi. 115.40 South } given : Variation required ?

Ans. The Variation is 20d. 12m. East.

But the Variation may be found most readily by an Instrument called a *Rectifier*, whose Description is as follows :

The Rectifier described. Plate 10.

This Instrument consisteth of two Parts, which are two Circles laid one upon another, and so fastened together in their Centers, that they represent two Compasses, one fixed, the other moveable ; each of them is divided into the 32 Points of the Compass, and 360 Degrees, and numbred both ways, from the North, and from the South ; ending at the East, and West, in 90 Degrees.

The Fixed Compass, represents the Horizon, in which the North, and all the Points of the Compasses are fixed, and immoveable.

The moveable One, represents the Mariner's Compass steered by, in which the North, and all other Points are liable to Variation.

In the Center of the moveable Compass, is fastened a Silk Thread, long enough to reach the out-side of the fixed Compass ; But when it's made of Wood, there is an Index instead thereof : The Use is as follows.

1. *To find the Variation by the Rectifier.*

Note ; Those Degrees numbred from the North, and the South towards the East, are termed the Right-hand, and the others towards the West, are called the Left-hand.

Example 1. At Sun-rising, suppose the true Amplitude 57d. from the North, and the Magnetic 73d. from the North, What is the Variation of the Compass, and which way ?

Place 73d. (from the North) on the Right-hand in the moveable Compass, to 57d. (from the North) on the Right-hand in the Immoveable Compass ; then the North Point of the Moveable Compass, will stand at 16d. on the Left-hand in the Immoveable Compass, which sheweth the Variation of the Compass is 16 Degrees West.

Example 2. In the Afternoon, let the true Azimuth be 80 Degrees from the North, and the Magnetic 101 deg. What is the Variation of the Compass, and which way ?

Place 101d. from the North ; that is, 79d. from the South
 on

Ch. X. *Variation of the Compass, by the Rectifier.* 261

on the Left-hand in the moveable Compass, to 80 deg. from the North, or Left-hand in the immoveable Compass; then the the North Point in the moveable Compass stands at 21 deg. on the Right hand in the immoveable Compass, which shews the Variation of the Compass to be 21 Degrees East.

Always counting Amplitude at Sun-rising, and Azimuth in the Forenoon, to the Right-hand, or towards the East; but at Sun-Setting, and in the Afternoon, count them to the Left-hand, towards the West.

2. *To rectify the Course by the Rectifier.*

This Proposition hath two Cases.

Case 1. The Variation of the Compass, and the Course steered, being given; to find the true Course.

Example 1. *Suppose the Variation be 21 Degrees East, and the Course steered by the Compass is NE by N. I demand the true Course, the Variation being allowed?*

1. Place the N. Point of the moveable Compass to 21d. from the North on the Right hand, in the immoveable Compass.

2. Lay the Thread or Index (which is fastned in the Center) over the N. E. by N. Point in the moveable Compass, keeping it streight out; then in the immoveable Compass the Thread or Index will lie on the 56 Degrees, or near N. E. by E. which is the true Course required.

Example 2. *The Variation 14 deg West, and the Course steer'd by the Compass, E S E. I demand the Ship's true Course?*

1. Place the North in the Moveable Compass, to 14 Deg. West, in the immoveable.

2. Stretch out the Thread, or Index, over E. S. E. in the Moveable, and it will lie on 82 Degrees in the Immoveable Compass, or E by S. a quarter E. the true Course required.

Case 2. *The Variation 21 deg. East, and the true Course given; to find the Course by the Compass.*

Example. *The Variation of the Compass and the true Course I should steer is N. E. by E. What Course must I steer by the Compass, to allow the Variation?*

1. Place the North, in the Moveable Compass to 21 Degrees East in the Immoveable Compass.

2. Stretch out the Thread over N. E. by E. in the Immoveable Compass, and then in the Moveable Compass, it will lie on 35 Degrees, or near NE by N. the Course you must steer to allow for the Variation of the Compass.

Here I thought to describe the Azimuth Compass, and how to observe by it; but considering it's an Instrument easily understood, that Discourse may be spared.

CHAPTER XI. *Of an Observation, either of Sun, or Star, what it is, how, or with what, and when 'tis taken, and finding the Latitude thereby.*

1. **A**N Observation, is the finding either the Sun's, or Star's Meridian Altitude (at Sea) with a Quadrant, or with a Cross-staff.

2. Meridian Altitude, is the Height above the Horizon of the the Sun, or Star, they being upon the Meridian of the Place of Observation; and that the Sun is, every Day at Noon, but the Stars at different Times, according to the difference of their several Right Ascensions from the Sun's Right Ascension.

3. A Quadrant is the Instrument whereby only the Sun's Altitude (at Sea) is found.

4. A Cross-staff or Fore-staff, is an Instrument whereby Mariners find either the Sun's, or Star's Altitude. The particular Description of these Instruments I here omit, having done it largely in the *Mariner's Compass Rectified*; to which Book I refer the Learner, and will now shew how to find the Latitude after you have observed, which is called, working an Observation, and that in this one Proposition.

Proposition. The Meridian Altitude of any Heavenly Object, and it's Declination given; to find the Latitude of the Place of Observation.

In this Proposition are two Cases.

Case 1. *Where, or when the Object observed doth both Rise and Set in 24 Hours. The Rules are these.*

Rule 1. The Meridian Altitude; and Declination of one kind: that is, both North, or both South; the Difference of the Zenith Distance, and the Declination, is the Lat. required.

Note, When the Declination is greater than the Zenith Distance, the Latitude is of the same Name; but if less, then of a contrary Name to the Declination.

Rule 2. The Meridian Altitude, and Declination of contrary Names; that is, one North, and the other South, the Sum of the Zenith Distance, and the Declination, is the Latitude required, of the same Name with the Declination.

Note 1. By Meridian Altitude South, I mean the Object observed is to the Southward of the Observer; and when North, then to the Northward of the Observer.

Note 2. By Zenith Distance understand the Complement of the Meridian Altitude of the Object observed.

Example 1. On the 20th of May 1740 the Sun's Meridian Altitude

Altitude 61d. 08m. South; and his Declination 22d. 00m. North, What is the Latitude of the Place of Observation?

	d. m.
The Sun's Zenith Distance ———	28 52 South
Sun's Declination ———	22 00 North

The Sum (by Rule 2.) is the Lat. of the Place 50 52 North

Example 2. On the 1st of July 1740, the Sun's Zenith Distance being 11d. 50m. North, and his Declination 21d. 58m. North. What is the Latitude of the Place of Observation?

	d. m.
From the Sun's Declination ———	21 58 North
Subtract the Sun's Zenith Distance ———	11 50 North

The Rem. (by Rule 1.) is the Lat. of the Place 10 08 North

Example 3. On the 3d of June 1740, the Sun's Zenith Distance being 29d. 15m. South, and his Declination then 23d. 19m. North. What is the Lat. of the Place of Observation?

	d. m.
To the Sun's Zenith Distance ———	29 15 South
Add his Declination ———	23 19 North

The Sum (by Rule 2.) is the Lat. of the Place 52 34 North

Example 4. On the 22d of March 1740, the Star *Famelhaut* being observed, and his Zenith Distance 20d. 17m. North, this Star's Declination (in page 178) is 31d. 03m. South. What is the Latitude of the Place of Observation?

	d. m.
To the Star's Zenith Distance ———	20 17 North
Add the Star's Declination ———	31 03 South
The Sum is the Latitude required ———	51 20 South

Example 5. The 30th of March, 1740, the Foot of the *Crofters* (by some called the *Cock's Foot*) a Star much used in Southern Voyages, being observed, his Meridian Altitude was 48d. 06m. South; this Star's Declination (in page 178) is 61d. 31m. South. What is the Latitude of the Place of Observation?

	d. m.
From the <i>Crofters</i> Declination ———	61 31 South
Subtract his Zenith Distance ———	41 54 South
The Remainder is the Latitude required ———	19 37 South

Case 2. Where, or when the Object observed doth neither Rise, nor Set in 24 Hours; that is, doth not in the Diurnal Motion, move below or under the Horizon.

Note 1. In some parts of this Earthly World, both the Sun and Stars do not rise or set, but are above the Horizon, and upon the Meridian of the same place twice in the Space of 24 Hours; and this lasteth but for some part of the Year with the Sun, but always with some Stars.

Note 2. When the Sun, or a Star, doth neither Rise or Set, it cometh upon the Meridian below or under the Pole; and then it's at the least Meridian Altitude.

Note 3. Some Stars in some Places come upon the Meridian both below, and also above the Pole; that is between the Zenith and the Pole, and then it's at the greatest Meridian Altitude.

Note 4. Where a Star cometh upon the Meridian both below, and also above the Pole, it's always to the Northward, both in its least and greatest Meridian Altitude, or else always to the Southward.

Note 5. Again there are some Stars come upon the Meridian, to the Northward, and below the Pole; and to the Southward between the Zenith and the Equinoctial; and also to the Southward, and below the Pole; and to the Northward between the Zenith and the Equinoctial.

Note 6. Where the Sun cometh to the Meridian below, or a Star, both above and below the Pole, the Latitude of that Place is of the same Name, with the Sun or Star's Declination: That is, if the Sun or Star's Declination be North, the Latitude of the Place is North; but South, when the Declination is South.

Note 7. For those Stars which never come (the Sun never doth come to the Meridian) above the Pole, at their greatest Meridian Altitude, the former two Rules serveth for to find the Latitude.

Then to find the Latitude by the Sun under the Pole, or Stars both under and above the Pole. The Rules are these.

Rule 3. The object observed, being on the Meridian below the Pole, the Sum of the Meridian Altitude, and Complement of the Declination, is the Latitude required, of the same Name with the Declination.

Rule 4. The object observed, being on the Meridian above the Pole, the Difference of the Meridian Altitude, and the Complement of the Declination is the Latitude required, of the same Name with the Declination.

Ex-

Example 1. *August* 1st, 1740, the Sun's Meridian Altitude below the Pole, or under the Pole, was found to be 5d. 00m. and his Declination 14d. 54m. North; What is the Latitude of the Place of Observation?

d. m.

To the Complement of the Sun's Declination 75 06 North.

Add his Meridian Altitude below the Pole — 5 30

The Sum (by *Rule 3.*) is the Latitude — 80 36 North.

Example 2. On *December* the 18th, 1740, the *Bull's Eye Aldebaran* came upon the Meridian under the Pole, and his Meridian Altitude was observed to be 9d. 10m. this Star's Declination (in Page 178) is 15d. 56m. North; What is the Latitude of the Place of Observation?

d. m.

To the Complement of *Bull's Eye* Declination — 74 4 North

Add his Meridian Altitude under the Pole — 9 10

The Sum (by *Rule 3*) is the Latitude — 83 14 North

Example 3. On *June* the 11th, 1740, the Foot of the *Crossers* was observed under the Pole, its Meridian Altitude 21d. 25m. the Declination of this Star (in page 178) is 61d. 15m. South: I demand the Latitude of this Place of Observation?

d. m.

To the Complement of the Star's Declination 28 29 South

Add his Meridian Altitude — 21 25

The Sum (by *Rule 3.*) is the Latitude — 49 54 South

Example 4. The 17th of *February*, 1740, the *Northern Pointer* of the *Great Bear* came to the Meridian above the Pole, and his Meridian Altitude was 56d. 10m. this Star's Declination is 63d. 14m. North: What is the Latitude of the Place of the Observer?

d. m.

From the Star's Meridian Altitude, above the Pole 56 10

Subtract the Complement of his Declination — 26 46 North

Remainder (by *Rule 4.*) is the Latitude — 29 24 North

Chapter XII. *A Sea-Reckoning, or Journal, what it is, and the manner how it's kept, Directions to correct it, with an Example, and the Explanation thereof.*

THE keeping a good Reckoning or Journal, is not only the *Mariner's* Reputation, but (under God) the Preservation

tion of a Ship, and all in it; the Ignorance thereof has been, (if not the only, I may say) the chief Cause of losing divers rich Ships, and many dear Lives, and thence the impoverishing of several Families.

Then certainly, it should be their great Concern, to be expert herein, who take on them the Navigating Ships to remote Places, when so great a Trust as Mens Lives and Estates are reposed in them, that so, by a Knowledge of, and a constant careful Practice in keeping an exact Journal, they may not only bear the Name of *Navigators*, but thereby prove themselves deservedly worthy of the Title of *Compleat Artists*.

And for a compleat keeping a Journal, I prefer this Method hereafter following; which tho' it be new, and used by few, yet I doubt not, when better known, it will be more used: Now that you may rightly understand what it is, and how to keep an Account of the Ships Way by this new Form, I will thus explain it.

1. Know that a Journal, or Sea-Reckoning, is a punctual writing down every Day (in a Book fit for that Purpose) the Course, Distance, Difference of Latitude, and Departure the Ship hath made, what Latitude and Longitude she is in; and also the Wind, Weather, with all Accidents and Occurrences that happen.

To perform which after the best manner, do these preparative Things.

First. Provide a Folio Book of 2, 3, or 4 Quire of large Paper; and let it be ruled like the Log-Board, (in *Page 65*) with 5 Columns, taking up about half the Breadth of each Page.

The five Columns may be marked or noted at the Head of each Column with Letters, thus;

H	} which stand- eth for	{	Hours, under it are the Hours of the Day.
K			Knots,
F			Fathoms,
C			Courses, which have been steered that Day.
W			Winds, which have blown that Day, &c.

Secondly. Rule 12 Lines cross the foresaid 5 Columns, and so far asunder, that on Occasion you may write two Lines of writing in the Spaces between those Lines; then will the same Ruling serve for an *East-India* Voyage, in which the Log is heaved out every Hour, and also for other Voyages where it's used every two Hours.

Thirdly

Thirdly, In the first Column (marked at the upper end with H) write down the Hours of the Day; that is for Common Voyages, 2, 4, 6, 8, 10, 12, and 2, 4, 6, 8, 10, and 12: But for the an *East-India* Voyage, 1, 2, 3, &c. to 12 at Midnight; then 1, 2, 3, &c. to 12 at Noon. And thus far is the Book fitted, and prepared to copy off the *Log-Board*.

Fourthly, Under these 5 Columns let there be ruled 12 short Columns, which may take up the whole Breadth of each Page of the Book. These may be intitled as in the Journal following this Course, in Pages 274 and 275) and need not any farther Explanation.

Now such a Book so ruled as here express'd, each Page thereof will contain two Days Sailing, with all appertaining thereunto, as shall afterwards appear.

First, Having a Journal Book thus prepared, and now on your departing, the first thing is to enter the Title of the Journal, which may be done thus: In the Top or Head of the first Page of the Journal-Book, write the Title thereof in Words after the Form immediately before the Journal, in page 273.

And now the Book is compleatly fit for the Use intended, and that is keeping a Sea Reckoning, after this manner.

2. Next under, or after the Title, (write in the blank Space between the 5th Column for the Wind, and the Side of the Book) the *Year, Month, Day* and *Hour*, you part with sight of the Land, and also the Circumstances and Actions attending the same, &c. as here you may see in the two first Sides of the Journal: which by reason of the smallness of this Book reacheth pages 274 and 275, which are to be esteemed but as one Page, or Side of the Journal.

3. Every Day at Noon, write in the 5 Columns the same you find written on the *Log Board*, which contain the Ship's Courses steered, Distances run by the Log, what Winds have blown, what Sails handed, and when.

4. In the vacant Space of the Right-hand of these 5 Columns (which takes up more than half the Breadth of the Book) express the Transactions of that Day, as Winds, Weather, Currents, setting of the Sea, handing of Sails, meeting or parting with Ships, Death of Men, Variation of the Compass, and all other Accidents and Occurrences whatsoever.

5. Then correct the several Courses, by allowing for Lee-wardway, Currents, and Variation, according to the Nature of them;

them ; and bring them into one Courſe (by Chapter 3. Section 4. of *Plain Sailing*, in page 64.) by which you will find the Ship's Diſtance, Difference of Latitude, and Departure from Meridian, which being ſet down in the Columns bearing thoſe Titles, then (by Chapter 3. Section 3. General Rule 3. in page 58.) find the Latitude the Ship is in, and ſet that in its proper Column : And (by Chapter 4. Section 3. Problem 5. of *Mercator's Sailing*, in pages 96 and 97, and by Section 2. of the ſame Chapter in page 91.) find the Longitude the Ship is in, and place that in the 12th and laſt Column ; and thus you finiſh the Days Work.

For *Leeward*, or *Lee-way*, the Allowances are ſuch as in theſe eight following Caſes.

First, The Ship being upon a Wind, allow one Point for *Lee-way*.

Secondly, The Wind blowing hard to cauſe one Top-fail to be taken in ; allow two Points for *Lee-way*.

Thirdly, When it blows ſo hard that both Top-fails are taken in, and the Sea runs high ; allow then three Points for *Lee-way*.

Fourthly, The Fore-fail being furl'd, and the Ship Tries under a Main-fail, and a Miſſon ; allow four Points for *Lee-way*, for ſhe then makes her way about four Points before the Beam (as the Sea Phraſe is.)

Fifthly, When the Ship Tries under a Main-fail only, ſhe then makes her way near three Points before the Beam, that is, near Five Points for *Lee-way*.

Sixthly, If the Ship Tries under a Miſſon only, her Way is about two Points before the Beam ; that is, allow fix Points for *Lee-way*.

Seventhly, When ſhe lies a Hull ; that is, with all her Sails furl'd, her way is one Point before the Beam, and then ſeven Points is her *Lee-way*.

Eighthly, If the Wind hath blown hard at WSW. and made the Sea run high, the Ship ſtemmeth South, and the Wind ſhifting to ESE. then whiſt the Sea continues to run high, it ſtrikes the Ship on the Lee-Bow, and abates the *Lee-way*.

Note ; In all thoſe eight Caſes, reſpect muſt be had to the ſmoothneſs of the Water, or the Sea's running high, and then the Allowances may be rectified with the greater Certainty, by ſetting the Ship's Wake by the Quarter of the Compaſs, placed on each Rail of the Ship's Quarter, which is uſually ſet there for that Purpoſe.

Theſe Directions, with a Conſideration of the Ship's Trim,
Sail

Sail aboard, Stress of Wind, and growth of the Sea, being put into Practice, will so improve the young Navigator's Judgment, that he'll seldom fail of making good Allowance for the Ship's Leeway.

6. After this manner are you to proceed every Day from Noon to Noon, which is the beginning and ending of the Day Astronomic, the Day by which the *Mariners* keep their Sea-Reckoning.

7. Remembring always to observe for the Latitude, when Opportunity presents, either by Sun or Stars; that being the chief thing to be depended on, and by which the Reckoning is confirmed or rectified, which is the next thing to be treated of.

8. When the Latitude by account agrees with the Latitude by Observation, then is the Reckoning confirmed, and you are sure it's kept well.

9. But if they disagree, then either the Ship hath out-run your Reckoning, or your Reckoning hath out-run the Ship: and there is some Error, either in the Course, Distance sailed, or both of them; Now to find where the Error lies, consider whether there be a Current, or no.

10. If there be a Current, try it, and find which way it sets, and how fast: and by that correct both Course and Distance; and if that makes the Reckoning Latitude to agree with the Observed Latitude, you have then truly corrected the Reckoning.

But if you, only by some probable Reason, conjecture there is a Current, then give what Allowance you think meet to the Difference of Latitude, and Departure, and see if that will reform your Reckoning Latitude, that it agree with the observed Latitude; if so you have guessed well (for you must ever keep to the Latitude by Observation, that being the principal thing to be relied upon) but if it will not agree with the Observed Latitude, it's to be supposed that there are Mistakes in your Conjecture, or some other Cause of this Error in the Reckoning.

11. When there's no Current, nor any Variation, or if there be either, or both, and they are allowed for according to Art and Reason, and yet will not agree with the Observed Latitude; then there is an Error either in Steerage, or in the Log, and to know in which it is, take this

General Rule.

Differ. of Latitude }
Departure ——— } the greater, the Error is in the { Log.
Course.

12. When there is an Error in the Course steered, you must (after the Allowance in the 10th and 11th Rules have been made)

made) then only correct the Difference of Latitude, and so make the Latitude by Account to agree with the Latitude by Observation, and the Work is done.

13. But when the Error lieth in the Log, the Distance is faulty, and this is that which most usually makes the Difference between the Observed Latitude, and the Latitude by the Account. And herein are two Cases.

Case 1. *In North Latitude, sailing towards the North; and in South Latitude, sailing towards the South.*

If the Observed Latitude be the greater, then hath the Ship out-run the Reckoning; but if it be the less, the Reckoning hath out-run the Ship.

Case 2. *In North Latitude, sailing towards the South; and in South Latitude, sailing towards the North.*

If the observed Latitude be greater, then hath the Reckoning out-run the Ship; but if it be the less, the Ship hath out-run the Reckoning.

14. When the Ship hath out-run the Reckoning, then is the Reckoning too little, and the Difference between the observed Latitude and Reckoning Latitude, must be added to the North or South Column in the Reckoning; and so doing it's corrected.

15. But when the Reckoning hath out-run the Ship, then is the Reckoning too great, and the Difference between the Observed Latitude and Reckoning Latitude, must be subtracted from the North or South Columns in the Reckoning; and so doing it's corrected.

16. To correct the Departure (the East, or West Column in the Reckoning) when the Error is in the Distance, do thus: Add up the N. S. E. and West Columns from the beginning, if it be the first Error; otherwise from the last Error, or from the last Observation to the Day of the present Error; in order to find the Difference of Latitude and Departure; as was shewed in adding up the Columns in a Traverse.

And then the Proportion to find the Error, or Correction in the Departure, is this;

As the Difference of Latitude, is to the Departure;

So is the Correction in Latitude, to the Correction in Departure.

Note; Correction in Latitude, is the Difference between the Observed Latitude, and Reckoning Latitude.

The Correction in Departure must be added to, or subtracted from the East or West Column in the Reckoning, according

ing to the 14th, or 15th Rule aforefaid ; and fo the Departure will be corrected.

17. To correct the Longitude do thus ; Find (by the Table of *Meridional Parts*) the Meridional Difference of Latitude, between the obferved Latitude, and the Reckoning Latitude, and then the Proportion is this :

As the Correction in Latitude, is to the Correction in Departure ;

So is the Meridional Difference of Latitude, to the Correction in Longitude.

Then according to the new Way of Computation of Longitude in the *Mariner's Compass Rectified*, if the Longitude, and its Correction be both Eaſt, or both Weſt, add ; but one Eaſt, and the other Weſt, ſubtract, and the Longitude is Corrected.

And having gone over the Rules, and Directions about keeping, and correcting a Sea-Reckoning, or Journal ; I will alſo give an *Example* of a Journal, of an intended Voyage from the *Lizard* towards *Barbadoes*, that the foregoing Rules may be the better underſtood.

And altho' this following Journal be but an *Example* of ſeven Days (being ſo deſigned that this Book might not ſwell too big) yet it may be of ſufficient Intelligence to a dilligent Reader, for the right underſtanding this Method of Keeping, and Correcting a Sea-Journal ; eſpecially if the following Explanation be deliberately compared with the preceding Directions ; and thereby as informing, as if the whole Series of the Voyage had been inſerted, which would have both augmented the Book and its Price, but not answerable to the Underſtanding thereof.

Having treated about Keeping and Correcting a Journal, which cannot well be done 'till the Errors in the Log-Line and Half-Minute-Glaſs, are rectified ; I think it neceſſary here to ſay ſomething of both.

The manner of keeping a Reckoning or Sea-Journal (by our *English* Navigators) is by the Log-Line, and Half-Minute Glaſs ; Ought not Care to be taken that they be true, elſe a Reckoning kept by them cannot be true ?

But it hath been an ancient Cuſtom, and ſtill is too much uſed, to meaſure 7 Fathom, or 42 Feet, between Knot and Knot on the Log-line, which is grounded on this Conjecture, That 5 Feet make a Peace, 1000 (ſuch) Paces a Mile, and 60 (ſuch Miles) make a Degree ; that is, a Degree contains 300000 Feet,

Feet, and a Mile (or Minute) 5000 Feet; and because an Half-Minute of Time is the 120th part of an Hour, and the 120th part of (a Mile) 5000 Feet, is almost 42 Feet, the measure commonly put between each Knot on the Log-Line.

But this Froneous Computation hath been sufficiently contradicted by Mr. *Oughtred*, Mr. *Norwood*, and others.

Mr. *Oughtred*, in his *Circles of Proportion*, in page 153, doth allow 66 $\frac{1}{2}$ Statute Miles to a Degree on the Earth, each Mile being 5280 Feet, so that in a Degree there are 349,800 Feet.

And Mr. *Richard Norwood* in his *Seaman's Practice*, page 43. doth prove a Degree on the Earth, to contain 367200 *English* Feet: but at length consents to allow 360000 Feet to a Degree, and so 6000 Feet the 60th part, to be one Minute, commonly called a Mile; so that 6000 Feet should be the Number from whence the Knots on the Log-Line ought to be deduced.

Therefore, if 6000 (the Feet in a Mile or Minute) be divided by 120 (the Half Minutes in one Hour) the Quotient is 50 Feet; for the Distance of each Knot, on the Log-line, and 25 Feet is half a Knot.

Now 5 being the one Tenth of 50, let each Fathom on the Log-Line contain 5 Feet; and then 5 of these Fathoms make an Half Knot, and 10 of them one Knot.

And according to these Measures, let every Man that would keep a true Reckoning, and give a good Account of his Voyage, be persuaded to mark his Log-Line, and not let Custom prevail above Reason.

Then it follows, That if a Ship runneth out one of these Knots in half a Minute, she runneth one Mile or Minute, (the 60th part or a Degree) in an Hour; if 2 Knots, then 2 Miles; if 3 Knots and 4 Fathoms, then Miles 3.4; that is, 3 Miles and 4 Tenths of a Mile in an Hour, and so for any other. And by such a Log-line is the following Reckoning kept.

The like Regard must be had, that the Half Minute Glass be of a just Length, otherwise no true Account of the Ship's Way can be kept: Now for that, take an approv'd Experiment, mentioned by Mr. *Philips*, in his *Advancement of Navigation*, the Second Part, Page 9. as follows.

An easy and exact Way to measure an Half-Minute Glass.

Ler a Plummet of any form or weight, be fastened to one end of a Thread, or Silk-string, that is 38 $\frac{1}{2}$ Inches long, and at the other end is a Loop or Noose, to hang it on a small Pin or Nail, fastened in any Place, so that the Plummet may swing freely.

Then the Loop of the String being hung on the Pin, the
String

String $38\frac{1}{2}$ Inches from the Center of Gravity to the Center of Motion; that is $38\frac{1}{2}$ Inches from the end of the Loop, to the middle of the Plummets; and the Plummets caused to swing; each of those Swings shall be a true Second of Time, and 30 of them the just Length of an Half-Minute-Glass.

Always counting the Swings both forward from, and backward to the Perpendicular, supposed to fall from the Pin whereon the String doth hang: For half a Second of Time is measured every time the Plummets passeth from the Perpendicular, to its utmost Swing either way.

But when the Ship hath any considerable Motion, make the String 7 Inches shorter, and there make a Knot to hold it by, between your Finger and Thumb; then by the Motion of the Hand, cause the Plummets to ascend to an Angle of about 60 Degrees, from the foresaid Perpendicular each way; then each Swing shall be equal to those before mentioned; So that by this Experiment you may measure a true Half Minute of Time without a Glass, and by it examine the Truth of any Glass.

A Journal of a VOYAGE

(By God's Permission) in the

George of LONDON. *A. B.* Commander.

FROM THE

Lizard in $\left\{ \begin{array}{l} \text{Latitude } 50^{\text{d.}} 00^{\text{m.}} \text{ North.} \\ \text{Longitude } 5^{\text{d.}} 24^{\text{m.}} \text{ West.} \end{array} \right.$

TO THE

Island Barbadoes in $\left\{ \begin{array}{l} \text{Latitude } 13^{\text{d.}} 25^{\text{m.}} \text{ North.} \\ \text{Longitude } 58^{\text{d.}} 04^{\text{m.}} \text{ West.} \end{array} \right.$

Their Difference of Longitude $52^{\text{d.}} 40^{\text{m.}} \text{ West.}$

The Course from the *Lizard*, $S. 49^{\text{d.}} 53^{\text{m.}} W. \text{ or } SW\frac{1}{2}W$

Their Distance in that Rumb, 3407 Minutes.

Kept by *C. D.* Chief Mate.

Began *January* ☉ 13th, 1740.

S

At

	H	K	F of 5 Feet	C	Wind and Weather.
Afternoon	2	5	2	W by N	N N E.
	4	5	—	W S W	N. Scilly N by W. 7 Leag. off
	6	5	6	—	N N E.
	8	5	5	—	—
	10	5	5	SW by W	NW by N Rain
	12	6	5	W S W	North Rain
After Midnight	2	6	1	—	N by E.
	4	6	1	—	—
	6	6	3	—	N.E. by N. Rain
	8	6	—	SW by W	—
	10	6	—	W S W	—
	12	6	—	—	E N E

fum'd up 69.5 ————— Which doubled, is Min. 139.6

Month Days	Week Days	Month and Year.	Course	Distance sailed in Minutes	Diff. of Lat. in Min.	
					N	S
13	⊙	Jan. 1740.	South	18	—	18.0
14	☾	—	W S W	137	—	51.4

⊙ The

☉ The 13th of *January*, 1740. At Noon we saw the *Lizard* Point bear North about 18 Minutes or Miles Distance of us : We had variable Winds, fresh Gales, close hazy rainy Weather, as *per Columns*.

In Company with the *Success*, Capt. E. F. Commander, bound for the *East-Indies*.

☾ 14th, our Course and Distance made good this Day, I make W. S. W. 157 Minutes, with Latitude, Meridional Distance, and Longitude, as *per Columns* underneath.

	d. m.		d. m.
☉ Zenith Distance —		☉ Magnet. Amplitude —	44.54 ES.
☉ Declination —		☉ True Amplitude —	30.39 ES.
Lat. by Obs. —		Variation —	14.15 W.

Depart. in Min.		Latitude by Account in deg. and min.	Meridional Distance in deg. and min.	Longitude by Account in deg. and min.
E	W			
		49.42 North		05 24 W.
	127.3	48.51 North	02.07 W.	08.37 W.

	H	K	F of 5 Feet	C	Wind and Weather.	
Afternoon	2	6	—	W S W.	N. E.	Rain and Snow
	4	6	—	S W		
	6	5	8		Rain and Snow.	
	8	7	1	SW by W	N E by E.	Rain
	10	7	—	W S W	E. N. E.	Rain
	12	7	1		N E by N.	Rain
After Midnight	2	7	—		N E	Lightning
	4	6	8	SW by W	N E by E.	
	6	7	2	W S W	N E	
	8	7	—		E N E.	Hail and Rain
	10	6	2			Rain
	12	6	6		E.	Rain
Sum is 79			8	Which doubled is Min. 159.6		

Days.	Months	Week	Days.	Month and Year.	Course	Distance Sailed in Minutes.	Diff. of Lat. in Min.	
							N.	S.
15	8			Jan. 1740.	swbw $\frac{1}{2}$ w	158		73.6

♂ The 15th of January 1740, hard Gales of variable Winds, with some Snow, Hail and Rain.

Our Top-sails Reef'd, and so have been ever since we saw the *Lizard*. A great swelling Sea following us, and setting towards the S S W.

Our Course and Distance I judge to be S. W. by W. half West, 158 Minutes, with Latitude, Meridional Distance and Longitude, as in the Columns underneath.

	d. m.		d. m.
☉ Zenith Distance	_____	☉ Magnet. Ampl.	_____
☉ Declination	_____	☉ True Ampl.	_____
Lat. by Observation	_____	Variation	_____

Depart. in Min.		Latitude by Account in deg. and min.	Meridional Distance in deg. and min.	Longitude by Account in deg. and min.
E	W			
	139.8	47.37 N.	04.27 W.	12.10 W.

S 3

Afternoon

	H	K	F of 5 Feet	C	Wind and Weather	
Afternoon	2	6	3	SW by W	E.	Hail and Rain
	4	7	3	S W		Handed Fore Top-Sail Rain
	6	8	—		NE	Rain
	8	7	6			
	10	8	2			
After Midnight.	12	8	—			
	2	8	—			
	4	8	—			
	6	8	—			Rain
	8	8	1			Handed Main-Top-Sail Rain
	10	6	7			
	12	6	2			

fum'd up 90 — 4

Which doubled is Min. 180.8

Month Days	Week Days	Month and Year.	Course	Distance sailed in Minutes	Diff. Lat. in Min.	
					N.	S.
17	♀	Jan. 1740.	S W.	181		125.9
		Correction by Observation Corrected				24.0
						149.9

♂ The

§ The 16th of January, 1740. was bad Weather, very hard Gales, thick Air, with some Hail and Rain.

A great Sea after us, setting towards the S S W. for these three Days past.

By Observation the Ship hath out-run the Reckoning 24 Minutes South, which being attributed to the S S W. Sea.

Our Course and Distance corrected, is S W by S. 3 quarters W. 204 Minutes, with Meridional Distance, and Longitude, as underneath.

	d. m.		d. m.
Zenith Distance	63.42 S.	☉ Mag. Ampl.	13.00 WS.
☉'s Declination	18.35 S.	☉ True Ampl.	27.10 WS.
Lat. by Observ.	45.7 N.	Variation	14.10 W.

Depart. in Min.		Latitude by Account in deg. and min.	Meridional Distance in deg. and min.	Longitude by Account in deg. and min.
E	W			
	129.4	45.31 N.	06.36 W.	15.19 W.
	09.9	00.24 S.	00.10 W.	00.14 W.
	139.3	45.07 N.	06.46 W.	15.33 W.

	H	K	F of 5 Feet	C	Wind and Weather	
Afternoon	2	5	7	SW by S.	N. E.	
	4	7	—	—	Set Main Top-Sail.	
	6	6	1	—	N E by N.	
	8	5	—	—		
	10	5	2	SW by W.	N E	
After Midnight.	12	4	3	S W.	N E	Rain
	2	5	5	—	N.	Rain
	4	6	3	—	N W by N.	
					Set Fore-Top Sail.	
	6	6	1	—		
	8	6	2	—	N.	
	10	6	—	SW by S $\frac{1}{2}$ W	NNE.	
	12	6	—	—		

sum'd up 69 ——— 4 Which doubled is Min. 138.8 Tenths

Month Days	Week Days	Month and Year.	Course	Distance sailed in Minutes	Diff. Lat. in Min	
					N.	S.
17	4	Jan. 17, 40.	SW by S $\frac{1}{2}$ W	138		104.2

4 The

4 The 17th of January, 1740, close Weather, with some Rain, fresh Gales, and variable; with a great Sea, from the NNE.

About 8 this Morning we saw a Sail on our Larboard Quarter, so far off that we could but just discern her.

Our Course and Distance made good this 24 Hours, is S. 41d. W. or SW. by S. half W. 138 Minutes, with Latitude, Meridional Distance, and Longitude, as here under.

	d.m.		d.m.
☉ Zenith Distance—		☉ Magnet. Amplitude	39.09 E.S.
☉ Declination —		☉ True Amplitude —	25.39 E.S.
Lat. by Obs.		Variation—	13.30 W.

Depart. in Min.		Latitude by Account in deg. and min.	Meridional Distance in deg. and min.	Longitude by Account in deg. and min.
E.	W			
	90.4	43.23 North	08.16 West	17.39 West

Afternoon

	H	K	F of 5 Feet	C	Wind and Weather.	
Afternoon	2	5	3	SSW.	NNE.	
	4	5				
	6	4	3			
	8	5	3		N by E.	
	10	6	2			Rain
	12	5	5			Rain
After Midnight	2	5				
	4	5			N by W.	Rain
	6	5	3			Rain
	8	5				Rain
	10	5	3			
	12	4	8			

Sum is 62 ——— 0 ——— Which doubled is Min. 124

Days.	Months	Week Days.	Month and Year.	Course	Distance Sailed in Minutes.	Diff. of Lat. in Min.	
						N.	S.
18	9		Jan. 1740.	S. S. W.	124		114.6

♀ The 18th of January 1740; clear Weather, intermixt with small Showers of Rain, fresh Gales, and a great Sea from the N N E.

About 6 this Morning we saw two Sails on our Larboa d-Bow, which we judged were *Turks Men of War*, who chased us till Sun-set, and could not get upon us; then they lay by, so we lost sight of them.

Our Course is S S W. 124 Minutes, with Latitude, Meridional Distance, and Longitude, as per Columns here under.

	d.m.		d.m.
☉ Zenith Distance ———		☉ Magnet. Amplitude ———	
☉ Declination ———		☉ True Amplitude ———	
Lat. by Observation —		Variation ———	

Depart. in Min.		Latitude by Account in deg. and min.	Meridional Distance in deg. and min.	Longitude by Account in deg. and min.
E.	W			
	47.4	41.28 North	09.03 West	18.44 West

Afternoon

	H	K	F of 5 Feet	C	Wind and Weather.
Afternoon	2	4	3	South	N.
	4	4	2		<i>Split Main Top-sail Brought another To.</i>
	6	5	—		
	8	5	2		NNE.
	10	5	6		Rain
After Midnight	12	5	7		N by E.
	2	5	5		Rain
	4	4	7		N.N.E. Rain
	6	5	3		
	8	6	1		NE by N.
	10	6	5		
	12	6	6		

(sum'd up 64 — 7 — Which doubled, is Min. 129.4

Days	Month	Week	Month and Year.	Course	Distance sailed in Minutes	Diff. of Lat. in Min.	
						N	S
19	h	—	Jan. 1740.	South	129.4	—	129.4

On The 19th of January 1740. Fresh Gales, uncertain Weather, and a NNE. Sea after us.

Yesterday, about Three in the Afternoon, in letting the Reef out of the Main Top-Sail, it split, which we unbent, and brought another To immediately.

Our Course is South 129 Minutes, with Latitude, Meridional Distance, and Longitude, as here under.

	d. m.		d. m.
☉ Zenith Distance	_____	☉ Mag. Ampl.	_____
☉ Declination	_____	☉ True Ampl.	_____
Lat. by Observation	_____	Variation	_____

Depart. in Min.		Latitude by Account in deg. and min.	Meridional Distance in deg. and min.	Longitude by Account in deg. and min.
E	W			
		39.19 N.	09.03 W.	18.44 W.

Afternoon

	H	K	F of 5 Feet	C	Wind and Weather.
Afternoon	2	6	1	S.	N N E.
	4	6	3		
	6	6	—		
	8	6	2		Rain
	10	6	5		E N E.
After Midnight	12	6	2		N E by N. Rain
	2	5	3		E N E. Rain
	4	5	—		N by E. and N by W.
	6	5	—		N by E. and E N E Rain
	8	5	5		
	10	5	8		N E by N.
	12	5	7		

Sum'd is 71 — 6 Which doubled is Min. 143.2 Tenths.

Month Days.	Week Days.	Month and Year	Course	Distance sailed in Minutes.	Diff Lat. in Min.	
					N.	S.
20	D	Jan. 1740.	S.	143		143.2
		Correction by Observation				34.0
		Corrected				177.2

On the 20th of January 1740. Fresh Gales with small Showers of Rain, a great Sea from the NNE.

Since the 16th Instant (the last Day of Observation) to this Day, I find we are more southerly 34 minutes than by Account; and with respect to the Sea) more Westerly 14 Minutes in Meridian Distance, which makes 17 Minutes in Longitude.

Our Course and Distance corrected by a good Observation, is S. 4d. 35m. W. or S. half W. 178 Minutes, with Latitude, Meridional Distance, and Longitude, as here under.

	d. m.		d. m.
☉ Zenith Distance	53.53 S.	☉ Mag. Ampl.	08.59 W S.
☉ Declination —	17.31 S.	☉ True Ampl.	22.19 W S.
Lat. by Observ.	36.22 N.	Variation —	13.20 W.

Depart, in Min.		Latitude by Account in deg. and min.	Meridional Distance in deg. and min.	Longitude by Account in deg. and min.
E	W			
		36.56 N.	09.03 W.	18.44 W.
	14.1	00.34 S.	00.14 W.	00.17 W.
	14.1	56.22 N.	00.17 W.	19.01 W.

The Explanation of the preceding Journal.

IN this Journal in the upper Part representing the Log-Book, there are five Columns, and in the lower part there are twelve Columns; all which have been described in the Directions immediately before the Journal (in page 266.) The Business now is to explain the Manner of proceeding in this Journal, and that is thus: The first Page of the Journal (in Page 274.) contains the Log-Board for the first Day after our departing the *Lizard*, which was ☉ the 13th of January, 1740, at Noon, the *Lizard* bore N. 18 Minutes Distance, &c. as in the Journal (Page 275) you may see.

Sunday ☉ But because the Week Day is expressed by a Character, which may not be understood by every one
Monday ☿ (tho' it's convenient so to write them) you have here
Tuesday ☽ the Week-Days with their Characters.
Wednesday ☿
Thursday ♃ And because the *Lizard* did bear North 18 Minutes
Friday ☿ Distance, therefore make the Course South, and place
Saturday ♄ 18m. in the Column, under Distance, &c. then the Difference of Latitude is 18m. which accordingly place in the South Column, and subtract it from the *Lizard* Lat. 50d. 00m. the Remainder 49d. 42m. is the Lat. the Ship is in, at parting sight of Land; which accordingly is placed in the Column, under Lat. by Account, &c. And in the last Column because the Course is South, place the Longitude of the *Lizard* 5d. 24m. West, and all that Day's Work is done.

Then from the 13th Day at Noon, to the 14th Day at Noon, you have the Courses and Distances for every two Hours with the Wind, and Weather, as they are taken from the Log-Board; as all other Circumstances attending, are there expressed; for the Particulars whereof, I refer to the Journal it self, in page 274. The several Courses and Distances of this Day, may be reduced to three Courses: Thus, *The Work of the 14th of January, 1740, being the first Days Sailing, in the preceding Journal, page 274.*

H	KF.
At 4 W SW.	5.0
6 The same	5 6
8 The same	5 5
12 The same	6.5
2 The same	6.1
4 The same	6.1
6 The same	6.3
10 The same	6.0
12 The same	6.0
Sum'd up is	53.1
That is W S W Min.	106.2

H	KF.
At 2 W by N	5.2
That is W by N.	10.4
At 10 SW by W	5.5
8 The same	6
Sum'd up is	11.5
That is, S W by W.	23 Min.

Courses	Dist.	N.	S.	E.	W.
W S W	106.2		40.6		98.1
W by N	10.4	2.0			10.2
SW by W	23.0		12.8		10.1
Distance	139.6		53.4	Dep.	127.4
			2.0		

Difference of Latitude 51.4

As Diff. Lat. .. Dép. : : Radius .. T. Course.

As m. $51\frac{1}{4}$.. m. $127\frac{1}{4}$: : T. 45d. .. T. 68d. (*SW.* or *WSW.*)

Then, As Sine Course .. Depart. : : Radius .. Distance.

As S. 68d. 00m. .. m. 127.4 : : S. 90d. .. m. 137.4 .

So that the Course made good, is S. 68d. 00m. Westerly, or WSW. nearest, and the Distance 137 Min. 4 Tenths; which place in their proper Columns, as may be seen in the first Day of the *Journal*, at the Foot thereof in Page 274.

The Difference of Latitude m. $51\frac{1}{4}$ (or nearest 51 Minutes) being Southerly, subtract from 49d. 42m. the Latitude at parting sight of Land, the Remainder 48d. 51m. place under Latitude by Account, for the Latitude the Ship is now in.

Again, the Departure 127.4 Minutes being reduced into Degrees make 102d. 7m. Westerly, which place in the Column under Meridian Distance, &c. in Page 275.

Lastly, To find the Longitude the Ship is now in, you have both Latitudes 49d. 42m. and 48d. 51m. the present Latitude, and the Latitude of the Day before, with the Departure min. 127.4, by which find the Difference of Longitude as directed in Problem 5. of *Mercator's Sailing*, in Pages 96 and 97, where the Proportion is,

As the Difference of Latitude, is to the Departure; So is the Meridional Difference of Latitude, to the Difference of Longitude.

	d m		Min.	
○ 13	} Lat. {	49.42	} Merid. Parts {	3447
○ 14		48.51		3369
				found in the Table of Meridional Parts

The Meridional Difference of Latitude 78 Then say,
As $51\frac{1}{4}$ m. .. m. $127\frac{1}{4}$: : m. 78 .. 193m. or 3d. 13m. Westerly,
which being added to the Longitude of the Day before 5d. 24m.
the Sum 8d. 37m. West is the present Longitude, which place
in the last Column of the *Journal*: Then that Day's Work is
finish'd.

Then, from the 14th Day at Noon, to the 15th Day at Noon (in the two next Pages of the *Journal*) the Courses and Distances for every two Hours, the Wind and Weather, with other Circumstances attending, taken from the *Log-Board*, are set down; for the Particulars, see the *Journal* in Pages 276 and 277.

Now the several Courses and Distances of this Day are reduced thus;

The Work of the 15th of January, 1740, the second Day's Sailing in the preceding Journal, in Pages 276 and 277.

T

First

H.	K.F.	H.	K.F.
First, 2 WSW. 6		Secondly, 4 — SW. 6.	
10 The same 7		6 — The same 5.8	
12 — 7.1		Summed up, is — 11.8	
2 — 7.		That is S W. — 23.6	
6 — 7.2		Thirdly, 8 SW by W. 7.1	
8 — 7.		4 The same 6.8	
10 — 6.2		Summed up, is — 12.9	
12 — 6.6		That is SW. by W. — 27.8	
Summed up, is 54.1			
That is WSW 108.2			

So that the Courses of this Day are these. WSW. m. 108.2. SW. m. 23.6 and SW. by W. m. 27.8, and by Chapter 3. Section 4. of Plain Sailing, in Pages 64 and 65, may be reduced into one Course as followeth.

Courses.	Dist.	N.	S.	E.	W.
W. S. W.	108.2		41.5		100.0
S. W.	23.6		16.7		16.7
S. W. by W.	27.8		15.4		23.1
Distance.	159.6	Lat.	73.6	Dep.	139.8

As Diff. Lat. .. Dep. :: Radius .. T. Course

As m. 73.6 .. m. 139.8 :: T. 45d. .. T. 62d. 15m. South Westerly, or SW. by W. $\frac{1}{2}$ W. is the Course made good.

As S. Course .. Departure :: Radius .. Distance.

As 62d. 15m. .. m. 139.8 :: S. 90d. .. 158 Minutes.

The Difference of Latitude m. 73.6 S. and the Depart. m. 139.8 West, make the Course S. 62d. 15m. W. or S. W. by W. $\frac{1}{2}$ W. and the Distance 158 Minutes; which place in their respective Columns in the Journal for the Day proposed, in Pages 276 and 277.

Then the Difference of Latitude m. 73.6 or 1d. 14m. being subtracted from the Latitude the Day before, 48d. 51m. the Remainder 47d. 57m. place under Latitude by Account, for the Latitude the Ship is now in, as in Page 277.

And the Departure m. 139.8 near 140 Minutes, being equal to 2d. 20m. is added to (because it's West, had it been East it should have been subtracted from) 2d. 7m. the Meridian Distance the Day before, and it makes 4d. 27m West, for the Ship's whole Meridian Distance from the Lizard, which place under it's proper Title, in Page 277.

Lastly, to find the Longitude the Ship is now in, you have the Latitude 48d. 51m. and 47d. 57m. the present Latitude, and the Latitude of the Day before, with the Departure m. 139.8 by which you may find the Difference of Longitude in this manner.

$\begin{matrix} \text{d. m.} \\ \text{14} \end{matrix} \left. \begin{matrix} \text{Lat.} \\ \text{15} \end{matrix} \right\} \begin{matrix} 48.51 \\ 47.37 \end{matrix} \left\{ \begin{matrix} \text{Mer. Parts} \\ \text{3369} \end{matrix} \right\} \begin{matrix} \text{found in the Table of Meridional Parts.} \\ 3457 \end{matrix}$

The Merid. Differ. of Latitude 112, And then say, As m. 73.6 :: 139.8 :: 112 m. :: m. 213, or 3d. 33 m. Westerly, which being added to the Longitude of the Day before, 8d. 37 m. the Sum 12d. 10m. West, is the present Longitude, which place in the last Column of the Journal, in Page 277; and the second Days Work is finished.

Again. In the two next Pages of the Journal, are the Courses, Distances, Winds, &c. taken off the Log Board from the 15th Day at Noon, to the 16th, which are wrought as follows.

The Work of the 16th of January 174c, the third Day's Sailing in the preceding Journal.

Courses.	Dist.	N.	S.	E.	W.
8 W by W.	12.6		7.0		10.5
8 W. —	168.2		118.9		118.9
Distance	180.8	Diff. Lat.	125.9	Dep.	129.4

As Diff. Lat. .. Departure :: Radius .. T Course.

As m. 125.9 .. m. 129.4 :: T. 45d. .. T. 45d. 47m. South Westerly or SW. is the Ship's Course.

As S. Course .. Departure :: Radius .. Distance.

As S. 45d. 47m. W. .. 129.4 :: S. 90d. .. 180.5 Minutes.

By the Work above it's evident that the Difference of Latitude is m. 125.9 South, the Departure m. 129.4 West, which makes the Course S. 45d. 47m. W. or SW. and the Distance 181 Minutes very near, which place in the respective Columns, in the Journal for the 16th of January, in Pages 278 and 279.

Then the Difference of Latitude m. 125.9, or near 126 Minutes, equal to 2d. 6m. South, subtracted from the Latitude of the Day before, 47d. 37m. Remainder is the Latitude by Account, the Ship is in 45d. 31m. N. which place in the 10th Column, in Page 279.

And the Departure 129 Min. or 2d. 9m. West, being added to 4d. 27m. the Meridian Distance of the Day before, makes 6d. 36m. West, the whole Meridian Distance by Account from the Lizard, which place in the 11th Column of the Journal, in Page 279.

And now having both Latitudes 47d. 37m. and 45d. 31m. with the Departure m. 129.4; by them find the Difference of Longitude, thus, $\begin{matrix} \text{15} \\ \text{16} \end{matrix} \left. \begin{matrix} \text{Lat.} \\ \text{15} \end{matrix} \right\} \begin{matrix} 47d. 37m. \\ 45d. 31m \end{matrix} \left\{ \begin{matrix} \text{Merid Parts} \\ 5257 \\ 5074 \end{matrix} \right\} \begin{matrix} \text{Min.} \\ \text{found in the} \\ \text{Table of} \\ \text{Merid. Parts} \end{matrix}$

The Meridional Difference of Latitude—183 Min.

As m. 125.9 .. m. 129.4 : : 183m. .. 189m. or 3d. 9m. West is the Difference of Longitude, and being added to the Longitude of the Day before, 12d. 10m. the Sum 15d. 19m. is the Longitude (by Account) the Ship is now in ; which place in the last Column of the Journal, in Page 279 ; and this Days Work (as to the Account, or Dead Reckoning) is finished.

But on the said 16th of *January* at Noon, by a good Observation of the Sun, I find the Latitude 45d. 7m. North, whereas by the Journal, the Latitude is 45d. 31m. North, their Difference is 24m. South, that is, the Ship by Observation is 24 Minutes more Southerly than by the Reckoning.

Wherefore to correct the Latitude, place 24m. in the South Column, and add it to the Difference of Latitude m. 125.9, it makes min. 149.9 for the corrected Difference of Latitude ; Also subtract it from 45d. 31m. (the Latitude by Account) to make it agree with the Observation, as you see is done in the Journal for the said 16th Day, in Pages 278 and 279.

Then to correct the Departure, consider according to the 9th Rule in the Directions for keeping a Journal, preceding it in page 269, whether there be a Current or no, and consulting the Written Journal, I find, "*A great Sea after us, setting towards the SSW. for these three Days past* ; which I take to be the Cause of this Error of 24m. in the Reckoning Latitude. And therefore (by Problem 2. of *Plain Sailing* in page 61.) find what Departure a SSW. Course, with Difference of Latitude 24m. will make, which is thus.

As S. 6 Points .. 24m. : : S. 2 Points .. m. 9.9 the Correction in the Departure, which place in the West Column, and add it to the Departure m. 129.4, it makes 139.3, for the corrected Departure ; Also add it to 6d. 36m. (the Meridian Distance by Account) it makes 6d. 46m. the corrected Meridian Distance ; as you see in the 11th Column of the Journal in page 279. And to correct the Longitude by the 17th Rule for keeping a Journal (in pages 270 and 271) is thus :

	d. m.		min.	
Lat. by	{ Account 45.31 }	Mer. Parts	{ 3074 }	found in Table Merid. Parts.
	{ Observ. 45.07 }		{ 3040 }	
Correction in Latit. — 24 Mer. Diff. Lat. 34. Then,				

As 24 min. .. m. 9.9 : : 34 Min. .. 14 Min. the Correction in Longitude West ; which being placed in the last Column, and added (for that by the Second Case of the 13th Rule preceding the Journal, in Page 270, the Ship hath out-run the Rec-

Reckoning) to 15 deg. 19 min. the Longitude over it, the Sum 15d. 33m. write underneath, which is the Corrected Longitude the Ship is in.

Lastly, To find the Course and Distance agreeable to the Correction by Observation, you have the Corrected Difference of Latitude and Departure; which according to Problem 6. of *Plain Sailing*, in page 63, is thus:

As the Corrected Difference of Latitude, is to the Corrected Departure; So is Radius, to the Tangent of the Course Corrected. That is;

As m. 149.7 .. m. 139.3 :: T. 45d. .. T. 42d. 59m. South westerly, or SW by S. three quarters W. is the corrected Course.

As S. Course .. Departure :: Radius .. Distance.

As S. 42d. 59m. .. m. 139.3 :: S. 90d. .. 204m. corrected Dist.

So that the Course and Distance corrected by Observation is SW by S. three quarters W. 204 Minutes, which write in the Journal for the said Day, in page 279. Then the whole is finished, and the Reckoning set to Rights for that time.

And now, having largely shewed the manner of these three Days Sailing, how they are wrought, and placed in their proper Columns in the Journal, with an Example of a Correction by Cœlestial Observation; I leave the rest to the diligent Learner's Practice, for they are done after the same manner: And the 20th of *January* you'll meet with another Correction for your Trial, which you may perform, if you studiously compare this one Example with the preceding Rules and Directions, and with frequent Practice will sufficiently enlighten the Way, the Manner how, and the Means whereby, to keep a Sea Journal (in this easy and commodious new Method) with greater certainty than hath hitherto been Taught.

And to invite all to keep their Sea Journals after this New Method, which I dare presume will nearly quadrate with the Forms practiced by the Ingenious; I have caused Paper Books to be ruled and intituled (in all respects) like to the Journal foregoing.

Which you may be furnished with at Reasonable Rates, by *W. Mount and T. Page*, at *Poffern Row on Tower-Hill*.

Here follows several TABLES useful in Navigation, with their Descriptions and Uses briefly and fully explained.

I. A Table of the Difference of Latitude and Departure from the Meridian.

T 4

II. A

II. A Table of Meridional Parts, for the making *Mercator's Chart*, and the working Questions in that kind of Sailing.

III. A Table of Proportional Parts, for supplying every Minute of Latitude in the Table of Meridional Parts.

IV. A Table of Logarithms from 1 to 10.000.

V. A Table of *Artificial Sines, Tangents and Secants* to every Degree and Minute of the Quadrant, the Radius being 10.000000.

VI. A Table of *Angles*, which every Rhumb (or Point of the Compass) maketh with the Meridian.

All of them carefully Corrected, and exactly Printed.

Chapter I. *The Explanation, and general Use of the Table of Logarithms, and Table of Sines, Tangents and Secants.*

THE *Table of Logarithms* being of more general Use than any other, I begin with it, altho' it be one of the last in this Book.

Section 1. *The Use of the Table of Ten Thousand Logarithms* beginning at Page 315.

THIS *Table* hath its first Page divided into six Columns, and all the following Pages into seven Columns, and containeth the Logarithms for all Numbers, increasing in their Natural Order, from 1, to 10.000; after this manner.

1. The *First, Third and Fifth Columns* of Page 315, contain Numbers, encreasing in their Natural Order, from 1 to 100, the other three Columns contain the *Logarithms* of them.

2. The Left-hand Column of each following page (from page 316 to page 357) contains Numbers encreasing as before from 100, to 999; the next five Columns of each Page, contain the Logarithms of all Numbers from 1000, to 9999: Those on the Left-hand Page are distinguished at the Top with the Figures, 0|1|2 3|4, those on the Right-hand with these Figures, 5|6|7|8|9.

3. The Numbers in the Left-hand Column, (under *Num.*) in each Page, with the joining those Figures at the Top of the other Ten Columns, are extended from 1000 unto 9999.

4. The last Column of each Page under *Diff.* at the Top containeth the Difference of the Logarithms.

The manner of Reading them, and their general Use, shall be explained in the following Propositions.

Proposition 1. *A whole Number under 100, being given; to find the Logarithm thereof.*

The Rule. Turn to the Table of Logarithms, and in the First, Third,

Third, or Fifth Column, of page 315, under (*Num.*) at the Top, look for the given Number, and in the next Column under (*Logar.*) is the Logarithm sought.

Example. Suppose the given Number was 19; What is its Logarithm?

Look in the first Column of page 315, under (*Num.*) for 19, and in the next Column, under (*Logar.*) is 1.278754, which is the Logarithm of 19; After the same manner you will find the

$$\text{Logarithm of } \left\{ \begin{array}{c} 2 \\ 10 \\ 45 \\ 100 \end{array} \right\} \text{ to be } \left\{ \begin{array}{c} 0.301030 \\ 1.000000 \\ 1.653212 \\ 2.000000 \end{array} \right\}$$

Note 1. In every Logarithm, the first Figure (to the Left-hand) is called the Characteristic, Index, or Noting Figure, and it serveth to shew how many Places the Absolute or Natural Number, (thereunto belonging) doth contain.

Note 2. The Characteristic or Index of every Logarithm, is an Unit less than the Number of Places in its correspondent Absolute Number.

That is,

All Numbers from 1 to 10, the first Figure of their Logarithms is 0, from 10 to 100, is 1: from 100 to 1000 is 2; from 1000 to 10,000, is 3; from 10,000 to 100,000, the Characteristic or Index, of their Logarithm is 4, &c.

Proposition 2. A Number that consists of three Places, being given; to find its Logarithm.

The Rule. Seek the given Number in the first Column (of the Left-hand Page under (*Num.*) at the Top; just against that Number, and in the next Column under (o) at the Top, you will find a Number of 6 Places besides the Index Figure correspondent to the given Number; that intire Number is the Logarithm sought.

Example. I desire to know the Logarithm belonging to the Absolute Number 215?

In the first Column of page 320 under (*Num.*) you'll find 215, and right against it, in the next Column under (o) at the Top, is 332438, besides 2 the Index Figure proper for 215; the intire Logarithm is 2.332438, for the Number 215.

$$\begin{array}{l} \text{In like manner} \\ \text{the Logarithm of} \end{array} \left\{ \begin{array}{c} 21.5 \\ 2.15 \\ 0.215 \\ 0.369 \\ 3.69 \\ 36.9 \\ 369. \end{array} \right\} \text{ is } \left\{ \begin{array}{c} 1.332438 \\ 0.332438 \\ 1.332438 \\ 1.567026 \\ 0.567026 \\ 1.567026 \\ 2.567026 \end{array} \right\} \begin{array}{l} \\ \\ \\ \\ \text{In Page} \\ 328. \end{array}$$

Here

Here note, that when the given Number is a Decimal Fraction, the Index hath a dash over it, which by some is called a Negative, being it's the Index of a Logarithm whose correspondent Absolute Number is less than a Unit.

Proposition 3. *A Number consisting of four Places given; to find the Logarithm thereof.*

The Rule. Seek the three first Figures of the given Number in the Left-hand Column, under (Num.) and the Fourth or last Figure at the Top; then in the common Angle of Meeting is a Number of six Places (besides the Index Figure) before which if you place or prefix its proper Characteristic or Index, you'll then have the Logarithm sought.

Example. *What is the Logarithm of 2157?*

In the Left-hand Column of Page (320) under (Num.) find 215, and 7 at the Top of Page (321); then right against (215) and under 7 you'll find (besides its Index Figure) .333850; before which prefix its proper Index 3, and it's 3.333850, the Logarithm of 2157. In like manner.

The Logarithm of	{	215.7	}	is	{	2.333850	}	
		21.57				1.333850		
		2.157				0.333850		
		0.2157				1.333850		
		0.02157				2.333850		
		0.002157				3.333850		
		0.03695				2.567614		
		0.3695				1.567614		In Page 329
		3.695				0.567614		
		36.95				1.567614		
		369.5				2.567614		

Proposition 4. *A Logarithm being given; to find the Absolute Number thereunto belonging.*

This is but the Converse of the former Propositions, and therefore according to *Chapter 1. Note 2.* in page 295.

The Rule is, 1. The Characteristic or Index, will declare of how many Places the Correspondent *Absolute Number* doth consist.

2. For if the Index be (0) or (1) seek the given Logarithm in Page 315, of the Table of Logarithms: and when it's (2) seek it in the following Pages after page 315. But when it's 3, 4, or 5, &c. reject the Index, and seek the remaining Figures among the Logarithms as before, and the Number against it is the Number sought.

Ex.

Example. *Let the given Logarithm be 0.698970. What is the Absolute Number belonging thereunto?*

This Logarithm 0.698970, you will find in the second Column of Page 315, under (*Logar.*) at the Top, and right against it in the Left-hand Column under (*Num.*) there is (5) which is the Absolute Number sought.

Example 2. *I demand the Absolute Number Correspondent to this Logarithm 1.653212?*

Look down the fourth Column of Page 315, and you'll find 1.653212 under (*Logar.*) to stand against 45 under (*Num.*) which is the Number required.

Example 3. *What is the Absolute Number answerable to this Logarithm 2.332438?*

The Characteristic or Index 2, sheweth the Number sought doth consist of three Places; and in the second Column of the Left-hand Page under (0) at the Top; in Page (320) you will find the aforesaid Figures 2.332438 to stand against (215) in the first Column under (*Num.*) therefore the given Number sought is 215.

Example 4. *Suppose the given Logarithm be 3.333850; What is the Absolute Number agreeable thereunto?*

Reject 3 the Index, which declareth the Number sought consists of four Places; and then looking down the second Column of the Left-hand Page, you will in Page (320) find the nearest rejecting the Indices (being less than .333850 the given Logarithm) to be .332438, and the Number against it in the Left-hand Column is (215); then look a-cross the Pages in the same Line direct, towards the Right-hand, from the said 215, and under 7 at the Top in Page (321) you will find the given Logarithm .333850, therefore 215 in the Left-hand Column, and the 7 at the Top being put together, make 2157 the Number required.

Section II. *The Use of the Table of Artificial Sines, Tangents, and Secants, beginning in Page 358.*

THIS Table followeth next after the Table of Logarithms, and contains the *Logarithmic Sine, Tangent and Secant* of every Degree and Minute of the Quadrant, after this manner.

1. Every Page is divided into 8 Columns, the first and last of which contain the Minutes of every Degree, and the other 6, the Logarithmic Sine, Tangent and Secant of those Degrees and Minutes.

2. The

2. The $\left\{ \begin{array}{l} \text{Left-} \\ \text{Right-} \end{array} \right\}$ hand Column of each Page $\left\{ \begin{array}{l} \text{under} \\ \text{over} \end{array} \right\}$ *Min.* at the $\left\{ \begin{array}{l} \text{Head} \\ \text{Foot} \end{array} \right\}$ of the Table containeth the Minutes of those Degrees, which are $\left\{ \begin{array}{l} \text{less} \\ \text{more} \end{array} \right\}$ than 45, and increase in their $\left\{ \begin{array}{l} \text{Descent} \\ \text{Ascent} \end{array} \right\}$ from 0 to 60 Minutes.

The Explanation is in the Propositions following.

Proposition 5. *To find the Sine, Tangent, and Secant of any Degree and Minute given.*

The Rule. If the Degree be $\left\{ \begin{array}{l} \text{less} \\ \text{more} \end{array} \right\}$ than 45, it's found in those Columns which have the Words Sine, Tangent, Secant, at the $\left\{ \begin{array}{l} \text{Head} \\ \text{Foot} \end{array} \right\}$ of the Table.

Example 1. *I demand the Sine, Tangent, and Secant of 25d. 15m.*

Look for 25 Degrees (in page 408) at the Head or Top of the Table, in the first Column (of the Left-hand Page) under (*Min.*) at the Top, look downward for 15; against which, and (in page 408) under (*Sine*) you will find 9.629989, which is the Sine of 25d. 15m. Also against 15, and under *Tang.* you have 9.673602, the Tangent of 25d. 15m. Likewise against 15, and under *Secant*, you have 10.043613, the *Secant* of 25d. 15m.

Example 2. *Suppose you are to find the Sine, Tangent, or Secant of 33d. 45m.*

Turn to 33 Degrees (in page 424) at the Head of the Table, and in the first Column upon the Right-hand Page, under (*Min.*) at the Top (of page 425) find 45; right against which, and under (*Sine*) at the Head of the Table (in page 425) you will find 9.744739, which is the Sine of 33d. 45m. Also against 45, and under (*Tang.*) you'll have 9.824893 the Tangent of 33d. 45m. Likewise against 45, and under (*Secant*) is 10.081154, the *Secant* of 33d. 45m.

Example 3. *Let it be required to find the Sine, Tangent, or Secant of 56d. 15m.*

Seek 56 Degrees (in page 425) at the Foot or Bottom of the Table, and in the Right hand Column of (page 425) over (*Min.*) at the Foot of the Table, look upwards for 15; then

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Remainder according to Proposition 5. in page 298 : which will be the Sine Complement, Tangent Complement, or Secant Complement required.

Example. Suppose it be required to find the Sine Complement, Tangent Complement, or Secant Complement of 33d. 45m.

Subtract 33d. 45m. from 90 Degrees, the Remainder 56d. 15m. whose Sine, Tangent, or Secant, according to Proposition 5. in page 298 ; is the Sine Complement, Tangent Complement, or Secant Complement required.

Proposition 8. To find the Sine, Tangent, or Secant of any Number of Degrees and Minutes which exceed 90 Degrees.

The Rule. Subtract those Degrees and Minutes from 180 Degrees, and seek (according to Proposition 5. in page 298) the Sine, Tangent or Secant, of the Remainder, which will be the Sine, Tangent, or Secant required.

Example. Suppose you are to find the Sine of 132d. 17m.

Subtract 132d. 17m. from 180 Degrees, the Remainder is 47d. 43m. the Sine of which is the Sine required.

Proposition 9. To find the Complement Arithmetic of any Logarithm given.

The Complement Arithmetic of a Logarithm is, what it wanteth of 10.000000 or 20.000000, and is used to avoid Subtraction ; For finding it, this is

The Rule. Take the Residue or Remainder, of the first Figure to 9, and so of the rest, until you come to the last Figure, of which take its Remainder unto 10, and it's done.

Example 1. I would have the Complement Arithmetic of 9.625948 ?

For the first Figure 9 write 0 : for 6, 3 ; for 2, 7 ; for 5, 4 ; for 9, 0 ; for 4, 5 ; and for the last Figure 8, write 2. And so you have 0.374052, for the Complement Arithmetic sought.

Example 2. The Complement Arithmetic of 10.331327 required ?

For 0 (always rejecting the first Figure, when there are two Figures in the Characteristic) write 9 ; and so on as before directed ; and then you will have 9.668673, which is the Complement Arithmetic of 10.331327.

CHAPTER II. *The Explanation and Use of the Table of Difference of Latitude and Departure from the Meridian, in pages 306 and 307.*

THIS Table, tho' standing in so little room as two Pages, will give the Difference of Latitude and Departure for any Distance run, under 10.000; and for every Quarter Point of the Compass.

The Course stands at the Head and Foot of the Table; at the Head it begins at $\frac{1}{4}$ Point, and then $\frac{1}{2}$ Point, $\frac{3}{4}$ Point, increasing forwards to 4 Points.

At the Foot it begins at 4 Points, and then $4\frac{1}{2}$ Points, $4\frac{3}{4}$ Points, increasing backward to $7\frac{1}{4}$ Points.

The Distance Run is placed in the two outermost Columns of each Page, under and over the Word *Dist.* both at the Right-hand and at the Left-hand, beginning at 1; and increasing downward to 10, about half way each Page; and then beginning again at 1, and from thence increasing to 10, at the Foot of each Page.

The Difference of Latitude and Departure from the Meridian, stand under the Course at the Head of the Table, and over the Course at the Foot thereof; which are distinguished by the Words *Lat.* and *Dep.*

The Use of this Table shall be made evident in resolving a single Course (which is the first Case of *Plain Sailing*) and a Traverse, in these following Propositions.

Proposition 10. *Course and Distance Run given; to find the Difference of Latitude and Departure from the Meridian?*

Example 1. *Admit a Ship sails S by W $\frac{1}{2}$ W. 6 Minutes, I demand the Difference of Latitude and Departure from the Meridian?*

On the Left-hand in page 306, (of the Table under $1\frac{1}{4}$ Point, and right against 6 Minutes, under *Dist.* you will find (under the Word *Lat.*) 5.6492, and (under the Word *Dep.*) 2.2013, for the Difference of Latitude, and Departure required.

But it may suffice if the Difference of Latitude and Departure be taken only in Leagues or Minutes, and tenth Parts of a Minute, or League; with this Allowance, that is,

If the Parts be $\left\{ \begin{array}{l} 051 \\ 151 \\ 251 \\ 351 \\ 451 \\ 551 \\ 651 \\ 751 \\ 851 \end{array} \right\}$ or more, for it set down $\left\{ \begin{array}{l} 1 \\ 2 \\ 3 \\ 4 \\ 5 \\ 6 \\ 7 \\ 8 \\ 9 \end{array} \right\}$ Tenth
 $\left\{ \begin{array}{l} 1 \\ 2 \\ 3 \\ 4 \\ 5 \\ 6 \\ 7 \\ 8 \\ 9 \end{array} \right\}$ Tenth
 And

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And when the Parts are 951 or more, then make the Minutes or Leagues of *Difference of Latitude and Departure from the Meridian*, 1 more than they are in the Table. As for Instance;

Instead of $\left\{ \begin{array}{l} 3.151 \\ 6.151 \\ 7.259 \\ 8.960 \\ 9.959 \end{array} \right\}$ set down $\left\{ \begin{array}{l} 3.2 \\ 6.2 \\ 7.3 \\ 9. \\ 10. \end{array} \right\}$ hs Minutes or Leagues.

So then the aforesaid *Example S* by W. $\frac{1}{4}$ W. distance 6 min. being sought in the Table, finds as before;

The $\left\{ \begin{array}{l} \text{Difference of Lat } 5.6492 \\ \text{Departure } \text{---} 2.0213 \end{array} \right\}$ that is, $\left\{ \begin{array}{l} \text{Min. } 5.6 \text{ Tenths.} \\ \text{Min. } 2.0 \text{ Tenths.} \end{array} \right\}$

Example 2. A Ship sails SSW. W. 60 Minutes, I demand the Difference of Latitude and Departure from the Meridian?

To perform this, count 1, at the Beginning of the Table, to be 10, and 2 to be 20; 3, 30; 4, 40; 5, 50; 6, 60, &c. to 10, which now stands for 100. According to this Direction, against 6 (which now stands for 60) on the Right-hand Page 307, and under $2 \frac{1}{2}$ Points, stands 5.2915 under *Lat.* and 2.8284 under *Dep.* which makes the *Difference of Latitude* 52.913, or Min. 52.9 Tenths, and the *Departure* 28.284, or Min. 28.3 Tenths: For observe, That if the Distance be 6 Min. the *Difference of Latitude* is 5.291, and *Departure* 2.828. But,

If the $\left\{ \begin{array}{l} 60 \\ 600 \\ 6000 \end{array} \right\}$ Dist. be $\left\{ \begin{array}{l} \text{The} \\ \text{Diff. Lat. is} \end{array} \right\} \left\{ \begin{array}{l} 52.91 \\ 529.1 \\ 5291. \end{array} \right\}$ and $\left\{ \begin{array}{l} 28.28 \\ 282.8 \\ 2828.0 \end{array} \right\}$ Dep.

And after this manner you must increase the *Difference of Latitude and Departure*, as the Distance doth increase.

Example 3. Suppose a Ship sails ESE $\frac{1}{2}$ E. 65m. I demand the Difference of Latitude and Departure from the Meridian?

This must be look'd out of the Table at twice, that is, first find the *Difference of Latitude and Departure*, for Distance 60 Min. then find the *Difference of Latitude and Departure*, for Distance 5 Minutes, and add both together, which will shew you the *Differ. of Latitude and Departure*, required; As here under you may see: Min. Min. Min.

For Dist. $\left\{ \begin{array}{l} 60 \\ 5 \\ 65 \end{array} \right\}$ The Diff. Lat. is $\left\{ \begin{array}{l} 20.21 \\ 1.68 \\ 21.89 \end{array} \right\}$ and $\left\{ \begin{array}{l} 56.49 \\ 4.71 \\ 61.20 \end{array} \right\}$ Dep.

That is, according to the former Directions, the *Difference of Latitude* is 21.89, or Minutes 21.9 Tenths, and the *Departure* 61.20, or Minutes 61.2 Tenths, which was required.

Example 4. A Ship sails SW by S $\frac{1}{4}$ W. 137 Minutes, I demand the Difference of Latitude, and Departure from the Meridian?

This

Chap. H. The Use of the Table of Diff. of Lat. and Dep. 303

This must be taken out at thrice ; that is, seek the Difference of Latitude and Departure, for the Distance m.100, for m.30. and for m.7; add them together, as hereunder is done.

$$\begin{array}{rcl} \text{Min.} & & \text{Min.} \\ \text{For Dist. } \left\{ \begin{array}{l} 100 \\ 30 \\ \hline 137 \end{array} \right\} \text{ Diff. Lat. is } \left\{ \begin{array}{l} 80.32 \\ 24.10 \\ \hline 5.62 \\ 110.04 \end{array} \right\} \text{ and Dep. } \left\{ \begin{array}{l} 59.57 \\ 17.87 \\ \hline 4.17 \\ 81.61 \end{array} \right\} \end{array}$$

That is, Differ. of Lat. is 110 Min. and Dep. is m. 81.6 Tenths.

Proposition 11. Several Courses and Distances given ; to find the Differ. of Lat. and Depart. which is the resolving a Traverse.

Examp. Admit a Ship sails WSW. 106m. then W by N m.10.4 then SW by W. 23m. I demand the Difference of Latitude and Departure, direct Course, and Distance from the first Place?

These Courses and Distances are taken from the foregoing Journal, in page 274. being what the Log-Board made out for the first Day after departing from the Lizard.

In order to the working this by the Traverse Table, set down the several Courses, and Distances, as in the Table following.

Courses.	Dist. in min.	Difference of Latitude		Departure.	
		N.	S.	E.	W.
WSW	100.0		38 27		92.39
	6.0		2.30		5.54
W by N	10.0	1.95			9.81
	0.4	0.0			0.39
SW by W	20.0		11.11		16.63
	3.0		1.67		2.49
Summed up		2.03	53.35		127.25
Subtracted			2.03		
		Lat.	51.32	Dep.	127.25

Then by Prop. 1. find the Diff. of Lat. and Dep. for each several Course and Distance ; which place in their proper Columns : that is, if the Course be North Easterly, place the Difference of Latitude in the North Column under N. and the Departure in the East Column under E. If the Course be N. Westerly, place the Difference of Latitude in the N. Column under N. and the Departure in the West Column under W.

If the Course be South Easterly place the Diff. of Lat. in the S. Column under S. and the Departure in the East Column under E. but if the Course be South Westerly, place the Difference of Latitude in the South Column, and the Departure in the West Column.

As

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As for Instance, in the foregoing Table; the first Course is W S W. the Distance 106m. which is parted into two parts, viz. 100 and 6; and the Course being South Westerly, I place the Difference of Latit. m.38.27 under S. and the Dep. m.92.36 under W. The like I do for the Distance 6, as for Distance 100. The second Course is W by N. the Distance 10.4, which is also look'd out at twice; and the Diff. of Latitude 1.95, I place under N. and the Departure 9.81 under W. the like you must do for the rest.

Thus having found the Difference of Lat. and Departure for all the Course, and inserted their several Diff. of Lat. and Departures in their proper Columns; the next thing is to add up the N.E.S. and W. Columns, and set their Sums underneath.

Then subtract the N. and S. Columns, the less from the greater; and likewise the E. and W. Columns.

As in the foregoing Table the Sum of the N. Column is 2.03, of the S. 53.35, of the E. Column 0.00 and of the W. Column 127.25: And subtracting the N. Column from the S. the Remainder is 51.32 the Difference of Latitude Southerly.

And subtracting the E. Column from the W. the Remainder is 127.25 the Departure Westerly.

Now having the Difference of Latitude and Departure, you may find the Course and Distance by Chapter 3. Section 3. Problem 6. of *Plain Sailing*, in Page 63.

By which you will find the Course to be near W S W. the Distance 138 Minutes, as you may see in the Journal for the first Day thereof, in pages 274, 275, 288 and 289.

Chapter III. *The Use of the Table of Meridional Parts,* (beginning in page 308.)

THIS Table sheweth the Meridional Parts for every Minute of Latitude; and is thus to be understood:

In the first Column towards the Left-hand (of each page) are the Degrees of Latitude from 1 to 89 Degrees. In the next 6 Columns are the Meridional Parts for every 5 Minutes of Lat. answering to the Degrees in the first Column; which on the Left-hand Page are distinguished with | 0m | 5m | 10m | 15m | 20m | 25m | and on the Right-hand Page, with 30m | 35m | 40m | 45m | 50m | 55m | at the Head of the Table.

In the last Column of each Page towards the Right-hand is the Difference in Meridional Parts, to every 5 Minutes of Latitude; by the help of which, and the following Table of Proportional Parts, the Meridional Parts, to every Minute of Latitude may be found,

Proposition

Prop. 12. *To find the Merid. Parts to every 5 min. of Latitude.*

Examp. 1. *Suppose the Latitude of 13d. 10m. be given; to find the Meridional Parts belonging to it?*

Right against 13d. in the first Column of Page 308, and under 10m. (at the Head of the Table) in the 4th Column, you will find the Meridional Parts to be 797 Minutes.

Examp. 2. *Admit you were to find the Meridional Parts answering to the Latitude 50d. 10m?*

Right against 50d. in the first Column in Page 310, and under 10m. (at the Head of the Table) in the 4th Column, you will find 349c, which are the Meridional Parts required.

Chap. IV. *The Use of the Table of Proportional Parts, next following the Table of Meridional Parts, in Page 314.*

THE Use of this Table, is to find the Meridional Parts to every Minute of Latitude.

Prop. 13. *To find the Merid. Parts, for every Minute of Latitude.*

Examp. 1. *Suppose it was required to find the Meridional Parts for the Latitude 21d. 23m?*

First, Find the Meridional Parts for the Latitude 21d. 20m. (20m. being the next even 5, which is less than 23m.) which you will find in Page 308, to be 1311; and right against 21d. in the last Column (noted with the Difference at the Head of the Table) you will find 5.

Secondly, With this Difference 5, go to the Table of Proportional Parts, in Page 314, and look 5 (in the first Column thereof) under D, which stands for Difference, and because 23m. is 3 more than 20, look under 3 at the Head of the Fourth Column: So then right against 5 in the First Column, and right under 3, you will find 3, which add to 1311, and it makes 1314 minutes, the Meridional Parts for the Latitude 21d. 23m. required.

Examp. 2. *Let it be required to find the Meridional Parts answering to the Latitude 51d. 49m?*

The next less than 49m. is 45m. Therefore find the Meridional Parts for 51d. 45m. which is 3648, and right against 51d. in the Column of Difference is 8.

Now 49m. is 4m. above 45m. Therefore in the Table of Proportional Parts right against 8, and under 4, you will find the Proportional Parts to be 6; which add to 3648, makes 3654 min. the Merid. Parts for the Lat. 51d. 49m. required.

And thus much may suffice for the Use of these Tables, and for this Discourse, which I hope is plain and easy to every Reader.

A TABLE of Difference of Latitude and Departure from the Meridian.

Dif.	$\frac{1}{4}$ Point		$\frac{1}{2}$ Point		$\frac{3}{4}$ Point		1 Point		Dif.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.9988	0.0491	0.9952	0.0980	0.9892	0.1467	0.9808	0.1951	1
2	1.9976	0.0981	1.9903	0.1960	1.9784	0.2935	1.9616	0.3902	2
3	2.9964	0.1472	2.9855	0.2941	2.9675	0.4402	2.9424	0.5853	3
4	3.9952	0.1963	3.9807	0.3921	3.9567	0.5861	3.9232	0.7804	4
5	4.9940	0.2454	4.9759	0.4901	4.9459	0.7337	4.9040	0.9755	5
6	5.9927	0.2944	5.9711	0.5881	5.9351	0.8804	5.8847	1.1705	6
7	6.9915	0.3435	6.9663	0.6861	6.9243	1.0274	6.8655	1.3656	7
8	7.9903	0.3926	7.9615	0.7842	7.9134	1.1738	7.8463	1.5607	8
9	8.9891	0.4416	8.9567	0.8822	8.9026	1.3206	8.8271	1.7558	9
10	9.9879	0.4907	9.9519	0.9802	9.8918	1.4673	9.8079	1.9509	10
Dif.	Dep.		Dep.		Dep.		Dep.		Dif.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
$7\frac{1}{4}$ Points.		$7\frac{1}{2}$ Points		$7\frac{3}{4}$ Points		7 Points			

Diff.	1 $\frac{1}{4}$ Point		1 $\frac{1}{2}$ Point		1 $\frac{3}{4}$ Points		2 Points		Diff.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.9700	0.2430	0.9569	0.2903	0.9415	0.3369	0.9239	0.3827	1
2	1.9400	0.4860	1.9139	0.5806	1.8831	0.6738	1.8478	0.7654	2
3	2.9101	0.7289	2.8708	0.8709	2.8269	1.0107	2.7716	0.1480	3
4	3.8801	0.9719	3.8278	1.1612	3.7662	1.3476	3.6955	1.5307	4
5	4.8501	1.2149	4.7847	1.4515	4.7077	1.6845	4.6194	1.9133	5
6	5.8201	1.4579	5.7416	1.7417	5.6492	2.0213	5.5433	2.2961	6
7	6.7901	1.7009	6.6986	2.0320	6.5908	2.3582	6.4672	2.6788	7
8	7.7602	1.9438	7.6555	2.3223	7.5323	2.6851	7.3910	3.0614	8
9	8.7302	2.1868	8.6125	2.6146	8.4739	3.0320	8.3149	3.4441	9
10	9.7002	2.4298	9.5694	2.9029	9.4154	3.3689	9.2388	3.8268	10
Diff.	Dep.		Dep.		Dep.		Dep.		Diff.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
0 $\frac{1}{4}$ Points		0 $\frac{1}{2}$ Points		0 $\frac{3}{4}$ Points		6 Points			



A TABLE of Difference of Latitude and Departure from the Meridian.

Diff.	1 $\frac{1}{2}$ Points		2 $\frac{1}{2}$ Points		2 $\frac{1}{2}$ Points		3 Points		Diff.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.9040	0.4270	0.8819	0.4741	0.8577	0.5141	0.8315	0.5556	1
2	1.8080	0.8551	1.7638	0.9428	1.7155	1.0282	1.6629	1.1111	2
3	2.7120	1.2827	2.6458	1.4142	2.5732	1.5423	2.4944	1.6667	3
4	3.6160	1.7102	3.5277	1.8856	3.4302	2.0564	3.3259	2.2223	4
5	4.5200	2.1378	4.4100	2.3570	4.2887	2.5700	4.1574	2.7779	5
6	5.4240	2.5654	5.2915	2.8284	5.1464	3.0840	4.9888	3.3334	6
7	6.3280	2.9929	6.1734	3.2998	6.0041	3.5987	5.8208	3.8890	7
8	7.2320	3.4205	7.0554	3.7712	6.8618	4.1128	6.6518	4.4446	8
9	8.1360	3.8480	7.9373	4.2426	7.7196	4.6269	7.4832	5.0001	9
10	9.0400	4.2756	8.8192	4.7140	8.5733	5.1410	8.3147	5.5557	10
Diff.	5 $\frac{1}{2}$ Points		5 $\frac{1}{2}$ Points		5 $\frac{1}{2}$ Points		5 Points		Diff.
	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	

Diff.	3 $\frac{1}{2}$ Points		3 $\frac{1}{2}$ Points		3 $\frac{1}{2}$ Points		4 Points		Diff.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.8030	0.5957	0.7730	0.6344	0.7410	0.6716	0.7071	0.7071	1
2	1.6060	1.1914	1.5460	1.2988	1.4819	1.3431	1.4142	1.4142	2
3	2.4090	1.7871	2.3190	1.9032	2.2220	2.0147	2.1213	2.1213	3
4	3.2120	2.3828	3.0920	2.5376	2.9638	2.6802	2.8284	2.8284	4
5	4.0160	2.9800	3.8651	3.1720	3.7048	3.3578	3.5356	3.5356	5
6	4.8193	3.5742	4.6381	3.8064	4.4457	4.0294	4.2427	4.2427	6
7	5.6225	4.1699	5.4111	4.4408	5.1867	4.7009	4.9498	4.9498	7
8	6.4257	4.7656	6.1841	5.0752	5.9276	5.3725	5.6569	5.6569	8
9	7.2289	5.3613	6.9571	5.7096	6.6686	6.0448	6.3640	6.3640	9
10	8.0321	5.9570	7.7301	6.3440	7.4095	6.7156	7.0711	7.0711	10
Diff.	4 $\frac{1}{2}$ Points		4 $\frac{1}{2}$ Points		4 $\frac{1}{2}$ Points		4 Points		Diff.
	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	

A TABLE of Difference of Latitude and Departure from the Meridian.

Diff.	$\frac{1}{2}$ Point		$\frac{1}{2}$ Point		$\frac{1}{2}$ Point		1 Point		Diff.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.9988	0.0491	0.9952	0.0980	0.9892	0.1467	0.9808	0.1951	1
2	1.9976	0.0981	1.9903	0.1960	1.9784	0.2935	1.9616	0.3902	2
3	2.9964	0.1472	2.9855	0.2941	2.9675	0.4402	2.9424	0.5853	3
4	3.9952	0.1963	3.9807	0.3921	3.9567	0.5861	3.9232	0.7804	4
5	4.9940	0.2454	4.9759	0.4901	4.9459	0.7337	4.9040	0.9755	5
6	5.9927	0.2944	5.9711	0.5881	5.9351	0.8804	5.8847	1.1705	6
7	6.9915	0.3435	5.9663	0.6861	6.9243	1.0274	6.8655	1.3656	7
8	7.9903	0.3926	7.9615	0.7842	7.9134	1.1738	7.8463	1.5607	8
9	8.9891	0.4416	8.9567	0.8822	8.9026	1.3206	8.8271	1.7558	9
10	9.9879	0.4907	9.9519	0.9802	9.8918	1.4673	9.8079	1.9509	10
Diff.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Diff.
11	7 $\frac{1}{2}$ Points.		7 $\frac{1}{2}$ Points		7 $\frac{1}{2}$ Points		7 Points		11

Diff.	1 $\frac{1}{2}$ Point		1 $\frac{1}{2}$ Point		2 $\frac{1}{2}$ Points		2 Points		Diff.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.9700	0.2459	0.9569	0.2903	0.9415	0.3369	0.9239	0.3827	1
2	1.9400	0.4860	1.9139	0.5806	1.8831	0.6738	1.8478	0.7654	2
3	2.9101	0.7289	2.8708	0.8709	2.8279	1.0107	2.7716	0.1486	3
4	3.8801	0.9739	3.8278	1.1612	3.7662	1.3476	3.6955	1.5307	4
5	4.8501	1.2149	4.7842	1.4515	4.7077	1.6845	4.6194	1.9133	5
6	5.8201	1.4579	5.7416	1.7417	5.6492	2.0213	5.5433	2.2961	6
7	6.7901	1.7009	6.6986	2.0320	6.5908	2.3582	6.4672	2.6788	7
8	7.7601	1.9438	7.6535	2.3223	7.5323	2.6951	7.3910	3.0614	8
9	8.7301	2.1868	8.6125	2.6126	8.4739	3.0320	8.3149	3.4441	9
10	9.7002	2.4298	9.5694	2.9029	9.4154	3.3689	9.2388	3.8268	10
Diff.	Dep.		Lat.		Dep.		Lat.		Diff.
	6 $\frac{1}{2}$ Points		6 $\frac{1}{2}$ Points		6 $\frac{1}{2}$ Points		6 Points		



A TABLE of Difference of Latitude and Departure from the Meridian.

Dist.	1 1/2 Points		2 1/2 Points		3 1/2 Points		4 Points		Dist.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.9040	0.4276	0.8819	0.4741	0.8577	0.5141	0.8315	0.5556	1
2	1.8080	0.8551	1.7638	0.9428	1.7155	1.0282	1.6629	1.1111	2
3	2.7120	1.2827	2.6458	1.4142	2.5732	1.5423	2.4944	1.6667	3
4	3.6160	1.7102	3.5277	1.8856	3.4302	2.0564	3.3259	2.2223	4
5	4.5200	2.1378	4.4100	2.3570	4.2887	2.5700	4.1574	2.7779	5
6	5.4240	2.5654	5.2915	2.8284	5.1464	3.0840	4.9888	3.3334	6
7	6.3280	2.9929	6.1734	3.2998	6.0041	3.5987	5.8208	3.8890	7
8	7.2320	3.4205	7.0554	3.7712	6.8618	4.1128	6.6518	4.4446	8
9	8.1360	3.8480	7.9373	4.2426	7.7196	4.6265	7.4832	5.0001	9
10	9.0400	4.2756	8.8192	4.7140	8.5733	5.1410	8.3147	5.5557	10
Dist.	5 1/2 Points		6 1/2 Points		7 1/2 Points		8 Points		Dist.
	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	
1	0.9040	0.4276	0.8819	0.4741	0.8577	0.5141	0.8315	0.5556	1
2	1.8080	0.8551	1.7638	0.9428	1.7155	1.0282	1.6629	1.1111	2
3	2.7120	1.2827	2.6458	1.4142	2.5732	1.5423	2.4944	1.6667	3
4	3.6160	1.7102	3.5277	1.8856	3.4302	2.0564	3.3259	2.2223	4
5	4.5200	2.1378	4.4100	2.3570	4.2887	2.5700	4.1574	2.7779	5
6	5.4240	2.5654	5.2915	2.8284	5.1464	3.0840	4.9888	3.3334	6
7	6.3280	2.9929	6.1734	3.2998	6.0041	3.5987	5.8208	3.8890	7
8	7.2320	3.4205	7.0554	3.7712	6.8618	4.1128	6.6518	4.4446	8
9	8.1360	3.8480	7.9373	4.2426	7.7196	4.6265	7.4832	5.0001	9
10	9.0400	4.2756	8.8192	4.7140	8.5733	5.1410	8.3147	5.5557	10

Dist.	3 1/2 Points		4 1/2 Points		5 1/2 Points		6 Points		Dist.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.8030	0.5957	0.7730	0.6344	0.7410	0.6716	0.7071	0.7071	1
2	1.6064	1.1914	1.5460	1.2988	1.4819	1.3431	1.4142	1.4142	2
3	2.4096	1.7871	2.3190	1.9032	2.2220	2.0147	2.1213	2.1213	3
4	3.2128	2.3828	3.0920	2.5376	2.9638	2.6802	2.8284	2.8284	4
5	4.0161	2.9800	3.8651	3.1720	3.7048	3.3578	3.5456	3.5456	5
6	4.8193	3.5742	4.6381	3.8064	4.4457	4.0294	4.2427	4.2427	6
7	5.6225	4.1699	5.4111	4.4408	5.1867	4.7009	4.9498	4.9498	7
8	6.4257	4.7656	6.1841	5.0752	5.9276	5.3725	5.6569	5.6569	8
9	7.2289	5.3613	6.9571	5.7096	6.6686	6.0448	6.3640	6.3640	9
10	8.0321	5.9570	7.7301	6.3440	7.4095	6.7156	7.0711	7.0711	10
Dist.	7 1/2 Points		8 1/2 Points		9 1/2 Points		10 Points		Dist.
	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	
1	0.9040	0.4276	0.8819	0.4741	0.8577	0.5141	0.8315	0.5556	1
2	1.8080	0.8551	1.7638	0.9428	1.7155	1.0282	1.6629	1.1111	2
3	2.7120	1.2827	2.6458	1.4142	2.5732	1.5423	2.4944	1.6667	3
4	3.6160	1.7102	3.5277	1.8856	3.4302	2.0564	3.3259	2.2223	4
5	4.5200	2.1378	4.4100	2.3570	4.2887	2.5700	4.1574	2.7779	5
6	5.4240	2.5654	5.2915	2.8284	5.1464	3.0840	4.9888	3.3334	6
7	6.3280	2.9929	6.1734	3.2998	6.0041	3.5987	5.8208	3.8890	7
8	7.2320	3.4205	7.0554	3.7712	6.8618	4.1128	6.6518	4.4446	8
9	8.1360	3.8480	7.9373	4.2426	7.7196	4.6265	7.4832	5.0001	9
10	9.0400	4.2756	8.8192	4.7140	8.5733	5.1410	8.3147	5.5557	10

The Deg. of Lat.	The Minutes of each Degree.						The Difference.
	0m.	5m.	10m.	15m.	20m.	25m.	
	The Meridional Parts.						
0	0	5	10	15	20	25	5
1	60	65	70	75	80	85	5
2	120	125	130	135	140	145	5
3	180	185	190	195	200	205	5
4	240	245	250	255	260	265	5
5	300	305	310	315	320	325	5
6	361	366	371	376	381	386	5
7	421	426	431	436	441	446	5
8	482	487	492	497	502	507	5
9	542	547	552	557	562	568	5
10	603	608	613	618	623	628	5
11	664	669	674	679	684	690	5
12	725	730	736	741	746	751	5
13	787	792	797	802	807	812	5
14	848	854	859	864	869	874	5
15	910	916	921	926	931	936	5
16	973	978	983	988	994	999	5
17	1035	1041	1046	1051	1056	1061	5
18	1098	1103	1109	1114	1119	1125	5
19	1161	1167	1172	1177	1183	1188	5
20	1225	1230	1236	1241	1246	1252	5
21	1289	1295	1300	1305	1311	1316	5
22	1354	1359	1364	1370	1375	1381	6
23	1419	1424	1429	1435	1440	1446	6
24	1484	1490	1495	1500	1506	1511	6
25	1550	1556	1561	1567	1572	1578	6
26	1616	1622	1628	1633	1639	1644	6
27	1684	1689	1695	1700	1706	1712	6
28	1751	1757	1762	1768	1774	1780	6
29	1819	1825	1831	1837	1842	1848	6

The Deg. of Lat.	The Minutes of each Degree.						The Difference.
	30m.	35m.	40m.	45m.	50m.	55m.	
	The Meridional Parts.						
0	30	35	40	45	50	55	5
1	90	95	100	105	110	115	5
2	150	155	160	165	170	175	5
3	210	215	220	225	230	235	5
4	270	275	280	285	290	295	5
5	330	335	340	345	350	355	5
6	390	395	400	405	410	415	5
7	450	455	460	465	470	475	5
8	510	515	520	525	530	535	5
9	570	575	580	585	590	595	5
10	634	639	644	649	654	659	5
11	695	700	705	710	715	720	5
12	756	761	766	771	776	782	5
13	818	823	828	833	838	843	5
14	880	885	890	895	900	905	5
15	942	947	952	957	962	968	5
16	1004	1009	1014	1020	1025	1030	5
17	1067	1072	1077	1082	1088	1093	5
18	1130	1135	1140	1146	1151	1156	5
19	1193	1199	1204	1209	1214	1220	5
20	1257	1262	1268	1273	1278	1284	5
21	1321	1327	1332	1338	1343	1348	5
22	1386	1392	1397	1402	1408	1413	6
23	1451	1457	1462	1468	1473	1479	6
24	1517	1522	1528	1533	1539	1544	6
25	1583	1589	1594	1600	1605	1611	6
26	1650	1656	1661	1667	1672	1678	6
27	1717	1723	1729	1734	1740	1746	6
28	1785	1791	1797	1802	1808	1814	6
29	1854	1860	1865	1871	1877	1883	6

The Deg. of Lat.	The Minutes of each Degree.						The Difference.
	1m.	5m.	10m.	15m.	20m.	25m.	
	The Meridional Parts.						
30	1888	1894	1900	1906	1912	1917	6
31	1958	1964	1970	1976	1981	1987	6
32	2028	2034	2040	2046	2052	2058	6
33	2100	2105	2111	2117	2123	2129	6
34	2171	2177	2184	2190	2196	2202	6
35	2244	2250	2257	2263	2269	2275	6
36	2318	2324	2330	2337	2343	2349	6
37	2393	2399	2405	2411	2418	2424	6
38	2468	2475	2481	2487	2494	2500	6
39	2545	2551	2558	2564	2571	2577	6
40	2623	2629	2636	2642	2649	2655	6
41	2702	2708	2715	2722	2728	2735	7
42	2782	2788	2795	2802	2809	2815	7
43	2863	2870	2877	2884	2891	2897	7
44	2946	2953	2960	2967	2974	2981	7
45	3030	3037	3044	3051	3058	3065	7
46	3116	3123	3130	3137	3144	3152	7
47	3203	3210	3217	3225	3232	3240	8
48	3292	3299	3306	3314	3322	3329	8
49	3382	3390	3397	3405	3413	3420	8
50	3474	3482	3490	3498	3506	3514	8
51	3569	3577	3585	3593	3601	3609	8
52	3665	3673	3681	3690	3698	3706	8
53	3764	3772	3780	3789	3797	3806	8
54	3865	3873	3882	3890	3899	3907	8
55	3968	3977	3985	3994	4003	4012	9
56	4074	4083	4092	4101	4110	4119	9
57	4183	4192	4201	4210	4220	4229	9
58	4294	4304	4313	4323	4332	4342	10
59	4409	4419	4429	4438	4448	4458	10

The Deg. of Lat.	The Minutes of each Degree.						The Difference.
	30m.	35m.	40m.	45m.	50m.	55m.	
	The Meridional Parts.						
30	1923	1929	1935	1941	1946	1952	6
31	1993	1999	2005	2011	2017	2022	6
32	2064	2070	2076	2082	2088	2094	6
33	2135	2141	2147	2153	2159	2165	6
34	2208	2214	2220	2226	2232	2238	6
35	2281	2287	2293	2299	2306	2312	6
36	2355	2361	2368	2374	2380	2386	6
37	2430	2437	2443	2449	2456	2462	6
38	2506	2513	2519	2526	2532	2538	6
39	2584	2590	2597	2603	2610	2616	6
40	2662	2669	2675	2682	2688	2695	6
41	2742	2748	2755	2762	2768	2775	7
42	2822	2829	2836	2843	2849	2856	7
43	2904	2911	2918	2925	2932	2939	7
44	2988	2995	3002	3009	3016	3023	7
45	3073	3080	3087	3094	3101	3108	7
46	3159	3166	3173	3181	3188	3195	7
47	3247	3254	3262	3269	3277	3284	8
48	3337	3344	3352	3359	3367	3374	8
49	3428	3436	3443	3451	3459	3467	8
50	3521	3529	3537	3545	3553	3561	8
51	3617	3625	3633	3641	3649	3657	8
52	3714	3722	3731	3739	3747	3755	8
53	3814	3822	3831	3839	3848	3856	8
54	3916	3925	3933	3942	3951	3959	8
55	4021	4029	4038	4047	4056	4065	9
56	4128	4137	4146	4155	4164	4173	9
57	4238	4247	4257	4266	4275	4285	9
58	4351	4361	4370	4380	4390	4399	10
59	4468	4478	4488	4497	4507	4517	10

The Deg. of Lat.	The Minutes of each Degree.						The Difference.
	0m.	5m.	10m.	15m.	20m.	25m.	
	The Meridional Parts.						
60	4527	4537	4547	4557	4568	4578	10
61	4649	4660	4670	4680	4691	4701	10
62	4775	4786	4796	4807	4818	4829	11
63	4905	4916	4927	4938	4949	4960	11
64	4039	5051	5062	5074	5085	5097	12
65	5179	5191	5203	5214	5226	5238	12
66	5324	5336	5348	5361	5373	5385	12
67	5474	5487	5500	5513	5526	5539	13
68	5631	5644	5658	5671	5685	5698	13
69	5795	5809	5823	5837	5851	5865	14
70	5956	5981	5995	6010	6025	6040	15
71	6146	6161	6177	6192	6208	6223	15
72	6335	6351	6367	6384	6400	6417	16
73	6534	6552	6569	6586	6603	6621	17
74	6746	6764	6782	6801	6819	6838	18
75	6970	6990	7009	7029	7048	7068	20
76	7210	7231	7252	7273	7294	7315	21
77	7467	7490	7512	7535	7557	7580	23
78	7745	7769	7793	7817	7842	7867	25
79	8046	8072	8099	8125	8152	8179	27
80	8375	8404	8433	8463	8492	8522	30
81	8739	8771	8803	8836	8869	8903	33
82	9145	9182	9218	9255	9292	9330	37
83	9606	9647	9689	9731	9774	9817	43
84	10037	10185	10234	10283	10334	10385	51
85	10765	10822	10881	10941	11002	11064	62
86	11533	11605	11679	11755	11832	11911	77
87	12522	12619	12719	12821	12927	13036	109
88	13916	14063	14216	14376	14543	14720	
89	16300	16595	16926	17289	17693	18153	

The Deg. of Lat.	The Minutes of each Degree.						The Difference.
	30m.	35m.	40m.	45m.	50m.	55m.	
	The Meridional Parts.						
60	4588	4598	4608	4618	4629	4639	10
61	4712	4722	4733	4743	4754	4764	10
62	4839	4850	4861	4872	4883	4894	11
63	4472	4983	4994	5005	5017	5028	11
64	5108	5120	5132	5143	5155	5167	12
65	5250	5263	5275	5287	5290	5311	12
66	5398	5411	5423	5436	5449	5461	13
67	5552	5565	5578	5591	5604	5617	13
68	5712	5725	5739	5753	5767	5781	14
69	5879	5894	5908	5922	5937	5951	14
70	6055	6070	6085	6100	6115	6130	15
71	6239	6255	6271	6287	6303	6319	16
72	6433	6450	6467	6483	6500	6517	17
73	6639	6656	6674	6692	6710	6728	18
74	6856	6875	6894	6913	6932	6951	19
75	7088	7108	7128	7149	7169	7189	20
76	7336	7358	7379	7401	7423	7445	22
77	7603	7626	7650	7673	7697	7721	24
78	7892	7917	7942	7968	7994	8020	26
79	8207	8234	8262	8290	8318	8347	28
80	8552	8583	8614	8644	8676	8707	31
81	8936	8970	9005	9036	9074	9110	36
82	9368	9407	9445	9485	9525	9565	40
83	9861	9906	9951	9996	10043	10089	46
84	10437	10489	10542	10597	10652	10707	55
85	11127	11192	11257	11324	11392	11462	68
86	11692	12075	12160	12247	12336	12428	89
87	13149	13266	13386	13511	13641	13776	
88	14956	15102	15311	15532	15775	16024	
89	18083	19309	20076	21065	22459	24837	

D.	1	2	3	4	D.	1	2	3	4
5	1	2	3	4	25	5	10	15	20
6	1	2	3	5	26	5	10	16	21
7	1	3	4	6	27	5	11	16	22
8	2	3	5	6	28	6	11	17	22
9	2	4	5	7	30	6	12	18	24
10	2	4	6	8	31	6	12	19	25
11	2	4	7	9	33	7	13	20	26
12	2	5	7	10	35	7	14	21	28
13	3	5	8	10	37	7	15	22	30
14	3	6	8	11	40	8	16	24	32
15	3	6	9	12	42	8	17	25	34
16	3	6	10	13	46	9	18	28	37
17	3	7	10	14	50	10	20	30	40
18	4	7	11	14	55	11	22	33	44
19	4	8	11	15	61	12	24	37	49
20	4	8	12	16	68	14	27	41	54
21	4	8	13	17	76	15	30	46	61
22	4	9	13	18	88	18	35	53	70
23	5	9	14	18	105	21	63	53	84
24	5	10	14	19	115	23	69	69	92

A

A Table of *Logarithms*

For Numbers increasing in their Natural Order, from an Unit to 10,000.

With a TABLE of Artificial, SINES, TANGENTS, and SECANTS, the RADIUS 10,000,000; and to every Degree and Minute of the *Quadrant*.

N.	Logar.	N.	Logar.	N.	Logar.
1	0.000000	34	1.531476	67	1.826075
2	0.301030	35	1.544068	68	1.832509
3	0.477121	36	1.556302	69	1.838849
4	0.602060	37	1.568202	70	1.845098
5	0.698970	38	1.579784	71	1.851258
6	0.778151	39	1.591065	72	1.857332
7	0.845098	40	1.602060	73	1.863323
8	0.903090	41	1.612784	74	1.869232
9	0.954242	42	1.623244	75	1.875061
10	1.000000	43	1.633465	76	1.880814
11	1.041393	44	1.643453	77	1.886491
12	1.079181	45	1.653211	78	1.892094
13	1.113943	46	1.662755	79	1.897627
14	1.146128	47	1.672098	80	1.903090
15	1.176091	48	1.681241	81	1.908485
16	1.204120	49	1.690196	82	1.913814
17	1.230449	50	1.698970	83	1.919078
18	1.255272	51	1.707570	84	1.924279
19	1.278754	52	1.716000	85	1.929419
20	1.301030	53	1.724276	86	1.934498
21	1.322219	54	1.732394	87	1.939519
22	1.342423	55	1.740363	88	1.944483
23	1.361728	56	1.748188	89	1.949390
24	1.380211	57	1.755875	90	1.954242
25	1.397940	58	1.763421	91	1.959041
26	1.414973	59	1.770852	92	1.963788
27	1.431364	60	1.778151	93	1.968483
28	1.447158	61	1.785330	94	1.973128
29	1.462398	62	1.792392	95	1.977724
30	1.477121	63	1.799340	96	1.982271
31	1.491362	64	1.806180	97	1.986772
32	1.505150	65	1.812913	98	1.991236
33	1.518514	66	1.819540	99	1.995645

Num.	0	1	2	3	4	Diff.
100	2.000000	2.000434	2.000868	2.001301	2.001734	438
101	2.004321	2.004751	2.005180	2.005609	2.006038	428
102	2.008600	2.009026	2.009451	2.009876	2.010300	424
103	2.012337	2.012756	2.013180	2.013600	2.014020	419
104	2.017033	2.017451	2.017868	2.018284	2.018700	416
105	2.021189	2.021603	2.022016	2.022428	2.022841	412
106	2.025306	2.025715	2.026124	2.026533	2.026942	408
107	2.029384	2.029789	2.030195	2.030600	2.031004	404
108	2.033421	2.033826	2.034227	2.034628	2.035029	400
109	2.037426	2.037825	2.038223	2.038620	2.039017	396
110	2.041393	2.041787	2.042182	2.042575	2.042969	393
111	2.045323	2.045714	2.046105	2.046495	2.046885	389
112	2.049218	2.049606	2.049993	2.050380	2.050766	386
113	2.053078	2.053463	2.053846	2.054230	2.054613	382
114	2.056905	2.057286	2.057666	2.058046	2.058426	379
115	2.060698	2.061075	2.061452	2.061829	2.062206	376
116	2.064458	2.064832	2.065206	2.065580	2.065953	372
117	2.068186	2.068557	2.068928	2.069298	2.069668	369
118	2.071882	2.072250	2.072617	2.072985	2.073352	366
119	2.075547	2.075912	2.076276	2.076640	2.077004	363
120	2.079181	2.079543	2.079904	2.080266	2.080626	360
121	2.082785	2.083144	2.083503	2.083861	2.084219	357
122	2.086360	2.086716	2.087071	2.087426	2.087781	355
123	2.089905	2.090258	2.090611	2.090963	2.091315	351
124	2.093422	2.093772	2.094122	2.094471	2.094820	349
125	2.096910	2.107257	2.097604	2.097951	2.098297	346
126	2.100370	2.100715	2.101059	2.101403	2.101747	343
127	2.103804	2.104145	2.104487	2.104828	2.105169	340
128	2.107210	2.107549	2.107888	2.108227	2.108565	338
129	2.110590	2.110926	2.111262	2.111598	2.111934	335
130	2.113943	2.114277	2.114611	2.114944	2.115278	333
131	2.117271	2.117603	2.117934	2.118265	2.118595	330
132	2.120574	2.120903	2.121231	2.121560	2.121888	328
133	2.123852	2.124178	2.124504	2.124830	2.125156	325
134	2.127105	2.127429	2.127752	2.128076	2.128399	323
135	2.130334	2.130655	2.130977	2.131298	2.131619	321
136	2.133539	2.133858	2.134177	2.134496	2.134814	318
137	2.136721	2.137037	2.137354	2.137670	2.137987	315
138	2.139879	2.140194	2.140508	2.140822	2.141136	314
139	2.143015	2.143327	2.143639	2.143951	2.144263	311
140	2.146128	2.146438	2.146748	2.147058	2.147367	309
141	2.149219	2.149527	2.149835	2.150142	2.150449	307
142	2.152288	2.152594	2.152900	2.153205	2.153510	305

from 1 to 10000.

(317)

Num	5	6	7	8	9	Diff.
100	2.002160	2.002598	2.003029	2.003467	2.003891	432
101	2.006466	2.006894	2.007321	2.007748	2.008174	428
102	2.010724	2.011147	2.011570	2.011993	2.012415	424
103	2.014940	2.015360	2.015779	2.016198	2.016615	419
104	2.019116	2.019532	2.019947	2.020361	2.020775	416
105	2.023252	2.023664	2.024075	2.024486	2.024896	412
106	2.027350	2.027757	2.028164	2.028571	2.028978	408
107	2.031408	2.031812	2.032216	2.032619	2.033021	404
108	2.035430	2.035830	2.036229	2.036629	2.037028	400
109	2.039414	2.039811	2.040207	2.040602	2.040998	396
110	2.043362	2.043755	2.044148	2.044540	2.044931	393
111	2.047275	2.047664	2.048053	2.048442	2.048830	389
112	2.051152	2.051538	2.051924	2.052309	2.052694	386
113	2.054996	2.055378	2.055760	2.056142	2.056524	382
114	2.058805	2.059185	2.059563	2.059942	2.060320	378
115	2.062582	2.062958	2.063333	2.063709	2.064083	376
116	2.066326	2.066699	2.067071	2.067443	2.067814	372
117	2.070038	2.070407	2.070776	2.071145	2.071514	369
118	2.073718	2.074085	2.074451	2.074816	2.075182	366
119	2.077368	2.077731	2.078094	2.078457	2.078819	363
120	2.080987	2.081347	2.081707	2.082067	2.082426	360
121	2.084576	2.084934	2.085291	2.085647	2.086004	357
122	2.088136	2.088490	2.088845	2.089198	2.089552	354
123	2.091667	2.092018	2.092370	2.092721	2.093071	351
124	2.095169	2.095518	2.095866	2.096215	2.096562	349
125	2.098644	2.098990	2.099335	2.099681	2.100026	346
126	2.102090	2.102434	2.102777	2.103119	2.103462	343
127	2.105510	2.105851	2.106191	2.106531	2.106870	340
128	2.108903	2.109241	2.109578	2.109916	2.110253	338
129	2.111270	2.111605	2.111940	2.112275	2.112609	335
130	2.115610	2.115943	2.116276	2.116608	2.116940	338
131	2.118926	2.119256	2.119586	2.119915	2.120245	330
132	2.122216	2.122543	2.122871	2.123198	2.123525	328
133	2.125481	2.125806	2.126131	2.126456	2.126781	325
134	2.128722	2.129045	2.129368	2.129690	2.130012	322
135	2.131939	2.132260	2.132580	2.132900	2.133219	320
136	2.135133	2.135451	2.135768	2.136086	2.136403	318
137	2.138303	2.138618	2.138934	2.139249	2.139564	315
138	2.141450	2.141763	2.142076	2.142389	2.142702	313
139	2.144574	2.144885	2.145196	2.145507	2.145818	311
140	2.147676	2.147985	2.148294	2.148603	2.148911	309
141	2.150756	2.151063	2.151370	2.151676	2.151982	306
142	2.153815	2.154119	2.154424	2.154728	2.155032	304

Num.	0	1	2	3	4	Diff.
143	2.155336	2.155640	2.155943	2.156246	2.156549	303
144	2.158362	2.158664	2.158965	2.159266	2.159567	301
145	2.161368	2.161667	2.161967	2.162266	2.162564	299
146	2.164353	2.164650	2.164947	2.165244	2.165541	297
147	2.167317	2.167613	2.167908	2.168203	2.168497	295
148	2.170262	2.170555	2.170848	2.171141	2.171434	293
149	2.173186	2.173478	2.173768	2.174060	2.174351	291
150	2.176091	2.176381	2.176670	2.176959	2.177248	289
151	2.178977	2.179264	2.179552	2.179839	2.180126	287
152	2.181844	2.182129	2.182415	2.182700	2.182985	285
153	2.184691	2.184975	2.185259	2.185542	2.185825	283
154	2.187521	2.187803	2.188084	2.188366	2.188647	281
155	2.190352	2.190612	2.190892	2.191171	2.191451	279
156	2.193125	2.193403	2.193681	2.193959	2.194237	278
157	2.195900	2.196176	2.196452	2.196729	2.197005	276
158	2.198657	2.198932	2.199206	2.199481	2.199755	274
159	2.201397	2.201670	2.201943	2.202216	2.202488	272
160	2.204120	2.204391	2.204662	2.204933	2.205204	271
161	2.206826	2.207095	2.207365	2.207634	2.207903	269
162	2.209515	2.209783	2.210051	2.210318	2.210586	267
163	2.212188	2.212454	2.212720	2.212986	2.213252	266
164	2.214844	2.215109	2.215373	2.215638	2.215902	264
165	2.217484	2.217747	2.218010	2.218273	2.218535	262
166	2.220108	2.220370	2.220631	2.220892	2.221153	261
167	2.222716	2.222976	2.223236	2.223496	2.223755	259
168	2.225309	2.225568	2.225826	2.226084	2.226342	258
169	2.227887	2.228144	2.228400	2.228657	2.228913	256
170	2.230449	2.230704	2.230960	2.231215	2.231470	254
171	2.232990	2.233250	2.233504	2.233757	2.234011	253
172	2.235528	2.235781	2.236033	2.236285	2.236537	252
173	2.238046	2.238297	2.238548	2.238799	2.239049	250
174	2.240549	2.240799	2.241048	2.241297	2.241546	249
175	2.243038	2.243286	2.243534	2.243782	2.244030	248
176	2.245513	2.245759	2.246006	2.246252	2.246499	246
177	2.247973	2.248219	2.248464	2.248709	2.248954	245
178	2.250420	2.250664	2.250908	2.251151	2.251395	243
179	2.252853	2.253096	2.253338	2.253580	2.253822	242
180	2.255272	2.255514	2.255755	2.255996	2.256237	241
181	2.257679	2.257918	2.258158	2.258398	2.258637	239
182	2.260071	2.260310	2.260548	2.260787	2.261025	238
183	2.262451	2.262688	2.262925	2.263162	2.263399	237
184	2.264818	2.265054	2.265290	2.265525	2.265761	235
185	2.267172	2.267406	2.267641	2.267875	2.268110	234

Num.	5	6	7	8	9	Diff.
143	2.156852	2.157154	2.157457	2.157759	2.158061	302
144	2.159868	2.160168	2.160408	2.160709	2.161068	301
145	2.162863	2.163161	2.163460	2.163757	2.164055	299
146	2.165838	2.166134	2.166430	2.166726	2.167022	297
147	2.168792	2.169086	2.169380	2.169674	2.169968	295
148	2.171726	2.172019	2.172311	2.172603	2.172895	292
149	2.174641	2.174932	2.175222	2.175512	2.175802	291
150	2.177536	2.177825	2.178113	2.178401	2.178689	289
151	2.180413	2.180699	2.180986	2.181272	2.181558	287
152	2.183270	2.183554	2.183839	2.184123	2.184407	285
153	2.186108	2.186391	2.186674	2.186956	2.187239	283
154	2.188928	2.189209	2.189490	2.189771	2.190051	281
155	2.191730	2.192010	2.192289	2.192567	2.192846	279
156	2.194514	2.194792	2.195069	2.195346	2.195623	278
157	2.197281	2.197556	2.197832	2.198107	2.198382	276
158	2.200029	2.200303	2.200577	2.200850	2.201124	274
159	2.202761	2.203033	2.203305	2.203577	2.203848	272
160	2.205475	2.205745	2.206016	2.206286	2.206556	271
161	2.208172	2.208441	2.208710	2.208978	2.209247	269
162	2.210853	2.211120	2.211388	2.211654	2.211921	267
163	2.213518	2.213783	2.214049	2.214314	2.214579	266
164	2.216166	2.216430	2.216694	2.216957	2.217221	264
165	2.218798	2.219062	2.219322	2.219584	2.219846	262
166	2.221414	2.221675	2.221936	2.222196	2.222456	261
167	2.224015	2.224274	2.224533	2.224792	2.225051	259
168	2.226600	2.226858	2.227115	2.227372	2.227630	258
169	2.229170	2.229426	2.229682	2.229938	2.230193	256
170	2.231724	2.231979	2.232233	2.232488	2.232742	254
171	2.234264	2.234517	2.234770	2.235023	2.235276	253
172	2.236789	2.237041	2.237292	2.237544	2.237795	251
173	2.239299	2.239550	2.239800	2.240050	2.240300	250
174	2.241795	2.242044	2.242293	2.242541	2.242790	249
175	2.244277	2.244524	2.244772	2.245019	2.245265	248
176	2.246745	2.246991	2.247236	2.247482	2.247728	246
177	2.249198	2.249443	2.249687	2.249932	2.250176	245
178	2.251638	2.251881	2.252125	2.252367	2.252610	243
179	2.254064	2.254306	2.254548	2.254790	2.255031	242
180	2.256477	2.256718	2.256958	2.257198	2.257439	241
181	2.258877	2.259116	2.259355	2.259594	2.259833	239
182	2.261263	2.261501	2.261738	2.261976	2.262214	238
183	2.263636	2.263873	2.264109	2.264345	2.264582	237
184	2.265996	2.266232	2.266467	2.266702	2.266937	235
185	2.268344	2.268578	2.268812	2.269046	2.269279	234

Num.	0	1	2	3	4	Diff.
186	2.269513	2.269746	2.269980	2.270213	2.270446	233
187	2.271841	2.272074	2.272306	2.272538	2.272770	232
188	2.274158	2.274389	2.274620	2.274850	2.275081	230
189	2.276462	2.276691	2.276921	2.277151	2.277380	229
190	2.278754	2.278982	2.279210	2.279439	2.279667	228
191	2.281033	2.281261	2.281488	2.281715	2.281942	227
192	2.283301	2.283527	2.283753	2.283979	2.284205	226
193	2.285557	2.285782	2.286007	2.286232	2.286456	225
194	2.287802	2.288025	2.288249	2.288473	2.288696	223
195	2.290035	2.290257	2.290480	2.290702	2.290925	222
196	2.292256	2.292478	2.292699	2.292920	2.293141	221
197	2.294466	2.294687	2.294907	2.295127	2.295347	220
198	2.296665	2.296884	2.297104	2.297323	2.297542	219
199	2.298853	2.299071	2.299289	2.299507	2.299725	218
200	2.301030	2.301247	2.301464	2.301681	2.301898	217
201	2.303196	2.303412	2.303628	2.303844	2.304059	216
202	2.305351	2.305566	2.305781	2.305996	2.306210	215
203	2.307496	2.307710	2.307924	2.308137	2.308351	213
204	2.309630	2.309843	2.310056	2.310268	2.310481	212
205	2.311754	2.311966	2.312177	2.312389	2.312600	211
206	2.313867	2.314078	2.314289	2.314499	2.314710	210
207	2.315970	2.316180	2.316390	2.316599	2.316809	209
208	2.318063	2.318272	2.318481	2.318689	2.318898	208
209	2.320146	2.320354	2.320562	2.320769	2.320977	207
210	2.322219	2.322426	2.322633	2.322839	2.323046	206
211	2.324282	2.324488	2.324694	2.324899	2.325105	205
212	2.326336	2.326541	2.326745	2.326950	2.327154	204
213	2.328380	2.328583	2.328787	2.328991	2.329194	203
214	2.330414	2.330617	2.330819	2.331022	2.331225	202
215	2.332438	2.332640	2.332842	2.333044	2.333246	202
216	2.334454	2.334655	2.334856	2.335055	2.335257	201
217	2.336460	2.336660	2.336860	2.337060	2.337260	200
218	2.338456	2.338656	2.338855	2.339054	2.339253	199
219	2.340444	2.340642	2.340840	2.341039	2.341237	198
220	2.342425	2.342620	2.342817	2.343014	2.343212	197
221	2.344392	2.344589	2.344785	2.344981	2.345178	196
222	2.346353	2.346549	2.346744	2.346939	2.347135	195
223	2.348305	2.348500	2.348694	2.348889	2.349082	194
224	2.350248	2.350442	2.350636	2.350829	2.351023	193
225	2.352182	2.352375	2.352568	2.352761	2.352954	193
226	2.354108	2.354301	2.354493	2.354684	2.354876	192
227	2.356026	2.356217	2.356408	2.356599	2.356790	191
228	2.357935	2.358125	2.358316	2.358506	2.358696	190

from 1 to 10000.

(321)

Num.	5	6	7	8	9	Diff
186	2.270674	2.270912	2.271144	2.271377	2.271609	233
187	2.273001	2.273233	2.273464	2.273696	2.273927	232
188	2.275311	2.275542	2.275772	2.276002	2.276232	230
189	2.277609	2.277838	2.278067	2.278296	2.278525	229
190	2.279895	2.280123	2.280351	2.280578	2.280806	228
191	2.282169	2.282395	2.282622	2.282849	2.283075	227
192	2.284431	2.284656	2.284882	2.285107	2.285332	226
193	2.286681	2.286905	2.287130	2.287354	2.287579	225
194	2.288926	2.289143	2.289366	2.289589	2.289812	223
195	2.291147	2.291369	2.291591	2.291813	2.292034	222
196	2.293362	2.293583	2.293804	2.294025	2.294246	221
197	2.295567	2.295787	2.296007	2.296226	2.296446	220
198	2.297760	2.297979	2.298198	2.298416	2.298635	219
199	2.299943	2.300160	2.300378	2.300595	2.300813	218
200	2.302114	2.302331	2.302547	2.302764	2.302980	217
201	2.304275	2.304490	2.304706	2.304921	2.305136	216
202	2.306425	2.306639	2.306854	2.307068	2.307282	215
203	2.308564	2.308778	2.308991	2.309204	2.309417	213
204	2.310693	2.310906	2.311118	2.311330	2.311542	212
205	2.312812	2.313023	2.313234	2.313445	2.313656	211
206	2.314920	2.315130	2.315340	2.315550	2.315766	210
207	2.317018	2.317227	2.317436	2.317645	2.317854	209
208	2.319106	2.319314	2.319522	2.319730	2.319938	208
209	2.321184	2.321391	2.321598	2.321805	2.322012	207
210	2.323252	2.323458	2.323664	2.323871	2.324077	206
211	2.325310	2.325516	2.325721	2.325926	2.326131	205
212	2.327359	2.327563	2.327767	2.327972	2.328176	204
213	2.329398	2.329601	2.329804	2.330008	2.330211	203
214	2.331427	2.331630	2.331832	2.332034	2.332236	202
215	2.333447	2.333649	2.333850	2.334051	2.334253	202
216	2.335458	2.335658	2.335859	2.336059	2.336259	201
217	2.337459	2.337659	2.337858	2.338058	2.338257	200
218	2.339451	2.339650	2.339849	2.340047	2.340246	199
219	2.341434	2.341632	2.341830	2.342028	2.342225	198
220	2.343409	2.343605	2.343802	2.343999	2.344196	197
221	2.345374	2.345570	2.345766	2.345961	2.346157	196
222	2.347330	2.347525	2.347720	2.347915	2.348110	195
223	2.349277	2.349472	2.349666	2.349860	2.350054	194
224	2.351216	2.351410	2.351603	2.351796	2.351989	193
225	2.353146	2.353339	2.353532	2.353724	2.353916	193
226	2.355068	2.355260	2.355451	2.355643	2.355834	192
227	2.356981	2.357172	2.357363	2.357554	2.357744	191
228	2.358886	2.359076	2.359266	2.359456	2.359646	190

Num.	0	1	2	3	4	Diff.
229	2.359835	2.360025	2.360215	2.360404	2.360593	184
230	2.361728	2.361917	2.362105	2.362294	2.362482	188
231	2.363612	2.363800	2.363988	2.364176	2.364362	188
232	2.365488	2.365675	2.365862	2.366049	2.366236	187
233	2.367356	2.367542	2.367728	2.367915	2.368101	186
234	2.369216	2.369401	2.369587	2.369772	2.369958	185
235	2.371068	2.371253	2.371437	2.371622	2.371806	184
236	2.372912	2.373096	2.373280	2.373464	2.373647	184
237	2.374748	2.374932	2.375115	2.375298	2.375481	183
238	2.376577	2.376759	2.376942	2.377124	2.377306	182
239	2.378398	2.378580	2.378761	2.378943	2.379124	181
240	2.380211	2.380392	2.380573	2.380754	2.380934	181
241	2.382017	2.382197	2.382377	2.382557	2.382737	180
242	2.383815	2.383995	2.384174	2.384353	2.384533	179
243	2.385606	2.385785	2.385964	2.386142	2.386321	178
244	2.387390	2.387568	2.387746	2.387923	2.388101	178
245	2.389166	2.389343	2.389520	2.389697	2.389874	177
246	2.390935	2.391111	2.391288	2.391464	2.391641	176
247	2.392697	2.392873	2.393048	2.393224	2.393400	176
248	2.394452	2.394627	2.394802	2.394977	2.395152	175
249	2.396199	2.396374	2.396548	2.396722	2.396896	174
250	2.397940	2.398114	2.398287	2.398461	2.398634	173
251	2.399074	2.399247	2.400020	2.400192	2.400365	173
252	2.401400	2.401573	2.401745	2.401917	2.402089	172
253	2.403120	2.403292	2.403464	2.403635	2.403807	171
254	2.404834	2.405005	2.405175	2.405346	2.405517	171
255	2.406540	2.406710	2.406881	2.407051	2.407221	170
256	2.408240	2.408409	2.408579	2.408749	2.408918	169
257	2.409933	2.410102	2.410271	2.410440	2.410608	169
258	2.411620	2.411788	2.411956	2.412124	2.412292	168
259	2.413300	2.413467	2.413635	2.413802	2.413970	167
260	2.414973	2.415140	2.415307	2.415474	2.415641	167
261	2.416640	2.416807	2.416973	2.417139	2.417305	166
262	2.418301	2.418467	2.418633	2.418798	2.418964	165
263	2.419956	2.420121	2.420286	2.420451	2.420616	165
264	2.421604	2.421768	2.421933	2.422097	2.422261	164
265	2.423246	2.423410	2.423573	2.423737	2.423901	164
266	2.424882	2.425045	2.425208	2.425371	2.425534	163
267	2.426511	2.426674	2.426836	2.426999	2.427161	162
268	2.428135	2.428297	2.428459	2.428621	2.428782	162
269	2.429752	2.429914	2.430075	2.430236	2.430398	161
270	2.431364	2.431525	2.431685	2.431846	2.432007	161
271	2.432969	2.433129	2.433290	2.433450	2.433610	160

from 1 to 10000.

(423)

Num.	5	0	7	8	9	Diff.
229	2.360783	2.360972	2.361101	2.361350	2.361539	189
230	2.362671	2.362859	2.363048	2.363236	2.363424	188
231	2.364551	2.364739	2.364926	2.365113	2.365301	188
232	2.365423	2.365610	2.365796	2.365983	2.366169	187
233	2.368287	2.368473	2.368659	2.368844	2.369030	186
234	2.370143	2.370328	2.370513	2.370698	2.370883	185
235	2.371991	2.372175	2.372360	2.372544	2.372728	184
236	2.373831	2.374015	2.374198	2.374382	2.374565	184
237	2.375664	2.375846	2.376029	2.376212	2.376394	183
238	2.377483	2.377670	2.377852	2.378034	2.378216	182
239	2.379305	2.379487	2.379668	2.379849	2.380030	181
240	2.381115	2.381296	2.381476	2.381656	2.381837	181
241	2.382917	2.383097	2.383277	2.383456	2.383636	180
242	2.384712	2.384891	2.385070	2.385249	2.385427	179
243	2.386499	2.386677	2.386855	2.387034	2.387212	178
244	2.388279	2.388456	2.388634	2.388811	2.388989	178
245	2.390051	2.390228	2.390405	2.390582	2.390758	177
246	2.391817	2.391993	2.392169	2.392345	2.392521	176
247	2.393575	2.393751	2.393926	2.394101	2.394276	176
248	2.395326	2.395501	2.395676	2.395850	2.396025	175
249	2.397070	2.397245	2.397418	2.397592	2.397766	174
250	2.398808	2.398981	2.399154	2.399327	2.399501	173
251	2.400538	2.400711	2.400883	2.401056	2.401228	173
252	2.402261	2.402433	2.402605	2.402777	2.402949	172
253	2.403978	2.404149	2.404320	2.404492	2.404663	171
254	2.405688	2.405858	2.406029	2.406199	2.406370	171
255	2.407391	2.407561	2.407731	2.407900	2.408070	170
256	2.409087	2.409257	2.409426	2.409595	2.409764	169
257	2.410777	2.410946	2.411114	2.411283	2.411451	169
258	2.412460	2.412628	2.412796	2.412964	2.413132	168
259	2.414137	2.414305	2.414472	2.414639	2.414806	167
260	2.415808	2.415974	2.416141	2.416308	2.416474	167
261	2.417472	2.417638	2.417804	2.417970	2.418135	166
262	2.419129	2.419295	2.419460	2.419625	2.419791	165
263	2.420781	2.420945	2.421110	2.421275	2.421439	165
264	2.422426	2.422590	2.422754	2.422918	2.423082	164
265	2.424064	2.424228	2.424392	2.424555	2.424718	163
266	2.425697	2.425860	2.426023	2.426186	2.426349	163
267	2.427324	2.427486	2.427648	2.427811	2.427973	162
268	2.428944	2.429106	2.429268	2.429429	2.429591	162
269	2.430559	2.430720	2.430881	2.431042	2.431203	161
270	2.432167	2.432328	2.432488	2.432649	2.432809	160
271	2.433770	2.433930	2.434090	2.434249	2.434409	160

Num.	0	1	2	3	4	Diff.
272	2.434789	2.434788	2.434888	2.435043	2.435207	159
273	2.435207	2.436322	2.436481	2.436640	2.436798	159
274	2.436798	2.437909	2.438067	2.438226	2.438384	158
275	2.438384	2.439491	2.439648	2.439806	2.439964	158
276	2.439964	2.441066	2.441224	2.441381	2.441538	157
277	2.441538	2.442636	2.442793	2.442950	2.443106	157
278	2.443106	2.444201	2.444357	2.444513	2.444669	156
279	2.444669	2.445760	2.445915	2.446071	2.446226	155
280	2.446226	2.447313	2.447468	2.447623	2.447778	155
281	2.447778	2.448861	2.449015	2.449170	2.449324	154
282	2.449324	2.450403	2.450557	2.450711	2.450865	154
283	2.450865	2.451940	2.452093	2.452247	2.452400	153
284	2.452400	2.453471	2.453624	2.453777	2.453930	153
285	2.453930	2.454997	2.455149	2.455302	2.455454	152
286	2.455454	2.456528	2.456670	2.456821	2.456973	152
287	2.456973	2.458033	2.458184	2.458336	2.458487	151
288	2.458487	2.459543	2.459694	2.459845	2.459995	151
289	2.459995	2.461048	2.461198	2.461348	2.461498	150
290	2.461498	2.462548	2.462697	2.462847	2.462997	150
291	2.462997	2.464042	2.464191	2.464340	2.464489	149
292	2.464489	2.465532	2.465680	2.465829	2.465977	149
293	2.465977	2.467016	2.467164	2.467312	2.467460	148
294	2.467460	2.468495	2.468643	2.468790	2.468938	147
295	2.468938	2.469969	2.470116	2.470263	2.470410	147
296	2.470410	2.471438	2.471585	2.471732	2.471878	146
297	2.471878	2.472903	2.473049	2.473195	2.473341	146
298	2.473341	2.474362	2.474508	2.474653	2.474799	145
299	2.474799	2.475816	2.475962	2.476107	2.476252	145
300	2.476252	2.477266	2.477411	2.477555	2.477700	145
301	2.477700	2.478711	2.478855	2.478999	2.479143	144
302	2.479143	2.480151	2.480294	2.480438	2.480582	144
303	2.480582	2.481586	2.481729	2.481872	2.482016	143
304	2.482016	2.483016	2.483159	2.483302	2.483445	143
305	2.483445	2.484442	2.484584	2.484727	2.484869	142
306	2.484869	2.485863	2.486005	2.486147	2.486289	142
307	2.486289	2.487280	2.487421	2.487563	2.487704	141
308	2.487704	2.488692	2.488833	2.488973	2.489114	141
309	2.489114	2.490099	2.490239	2.490380	2.490520	140
310	2.490520	2.491502	2.491642	2.491782	2.491922	140
311	2.491922	2.492900	2.493040	2.493179	2.493319	139
312	2.493319	2.494294	2.494433	2.494572	2.494711	139
313	2.494711	2.495683	2.495822	2.495960	2.496099	139
314	2.496099	2.497068	2.497206	2.497344	2.497482	138

from 1 to 10000.

(325)

Num.	5	6	7	8	9	Dig.
272	2.435366	2.435526	2.435685	2.435844	2.436003	159
273	2.436957	2.437116	2.437275	2.437433	2.437592	159
274	2.438542	2.438700	2.438859	2.439017	2.439175	158
275	2.440122	2.440279	2.440437	2.440594	2.440752	158
276	2.441695	2.441852	2.442009	2.442166	2.442323	157
277	2.443263	2.443419	2.443576	2.443732	2.443888	157
278	2.444825	2.444981	2.445137	2.445293	2.445448	156
279	2.446382	2.446537	2.446692	2.446848	2.447003	155
280	2.447933	2.448088	2.448242	2.448397	2.448552	155
281	2.449478	2.449633	2.449787	2.449941	2.450095	154
282	2.451018	2.451172	2.451326	2.451479	2.451633	154
283	2.452553	2.452706	2.452859	2.453012	2.453165	153
284	2.454082	2.454235	2.454387	2.454540	2.454692	153
285	2.455606	2.455758	2.455910	2.456062	2.456214	152
286	2.457125	2.457276	2.457428	2.457579	2.457730	152
287	2.458638	2.458789	2.458940	2.459091	2.459242	151
288	2.460146	2.460296	2.460447	2.460597	2.460747	151
289	2.461649	2.461799	2.461948	2.462098	2.462248	150
290	2.463146	2.463296	2.463445	2.463594	2.463744	150
291	2.464639	2.464787	2.464936	2.465085	2.465234	149
292	2.466126	2.466274	2.466423	2.466571	2.466719	149
293	2.467608	2.467756	2.467904	2.468052	2.468200	148
294	2.469085	2.469233	2.469380	2.469527	2.469675	147
295	2.470557	2.470704	2.470851	2.470998	2.471145	147
296	2.472025	2.472171	2.472317	2.472464	2.472610	146
297	2.473487	2.473633	2.473779	2.473925	2.474070	146
298	2.474944	2.475090	2.475235	2.475381	2.475526	146
299	2.476397	2.476542	2.476687	2.476832	2.476976	145
300	2.477844	2.477989	2.478133	2.478278	2.478422	145
301	2.479287	2.479431	2.479575	2.479719	2.479863	144
302	2.480725	2.480869	2.481012	2.481156	2.481299	144
303	2.482159	2.482302	2.482445	2.482588	2.482731	143
304	2.483587	2.483730	2.483872	2.484015	2.484157	143
305	2.485011	2.485153	2.485295	2.485437	2.485579	142
306	2.486430	2.486572	2.486714	2.486855	2.486997	142
307	2.487845	2.487986	2.488127	2.488269	2.488410	141
308	2.489255	2.489396	2.489537	2.489677	2.489818	141
309	2.490661	2.490801	2.490941	2.491081	2.491222	140
310	2.492062	2.492201	2.492341	2.492481	2.492621	140
311	2.493458	2.493597	2.493737	2.493876	2.494015	139
312	2.494850	2.494989	2.495128	2.495267	2.495406	139
313	2.496237	2.496376	2.496514	2.496653	2.496791	139
314	2.497621	2.497759	2.497897	2.498035	2.498173	138

Num.	0	1	2	3	4	Diff.
315	2.498311	2.498448	2.498586	2.498724	2.498862	138
316	2.499687	2.499824	2.499962	2.500100	2.500236	137
317	2.501059	2.501196	2.501333	2.501470	2.501607	137
318	2.502427	2.502564	2.502700	2.502837	2.502973	136
319	2.503791	2.503927	2.504063	2.504199	2.504335	136
320	2.505150	2.505286	2.505421	2.505557	2.505693	136
321	2.506505	2.506640	2.506775	2.506911	2.507046	135
322	2.507856	2.507991	2.508125	2.508260	2.508395	135
323	2.509202	2.509337	2.509471	2.509606	2.509740	134
324	2.510545	2.510679	2.510813	2.510947	2.511081	134
325	2.511883	2.512017	2.512150	2.512284	2.512417	133
326	2.513218	2.513351	2.513484	2.513617	2.513750	133
327	2.514548	2.514680	2.514813	2.514946	2.515079	133
328	2.515874	2.516006	2.516139	2.516271	2.516403	132
329	2.517196	2.517328	2.517460	2.517592	2.517724	132
330	2.518514	2.518645	2.518777	2.518909	2.519040	132
331	2.519828	2.519959	2.520090	2.520221	2.520352	131
332	2.521138	2.521269	2.521400	2.521530	2.521661	131
333	2.522444	2.522575	2.522705	2.522835	2.522966	130
334	2.523746	2.523876	2.524006	2.524136	2.524266	130
335	2.525045	2.525174	2.525304	2.525433	2.525563	130
336	2.526339	2.526468	2.526598	2.526727	2.526856	129
337	2.527630	2.527759	2.527888	2.528016	2.528145	129
338	2.528917	2.529045	2.529174	2.529302	2.529430	128
339	2.530200	2.530328	2.530456	2.530584	2.530712	128
340	2.531479	2.531607	2.531734	2.531862	2.531989	128
341	2.532754	2.532882	2.533009	2.533136	2.533263	127
342	2.534026	2.534153	2.534280	2.534407	2.534534	127
343	2.535294	2.535421	2.535546	2.535674	2.535800	126
344	2.536558	2.536685	2.536811	2.536937	2.537063	126
345	2.537819	2.537945	2.538071	2.538197	2.538322	126
346	2.539076	2.539202	2.539327	2.539452	2.539578	125
347	2.540329	2.540455	2.540580	2.540705	2.540830	125
348	2.541579	2.541704	2.541829	2.541953	2.542078	125
349	2.542825	2.542950	2.543074	2.543199	2.543323	124
350	2.544068	2.544192	2.544316	2.544440	2.544564	124
351	2.545307	2.545431	2.545554	2.545678	2.545802	124
352	2.546543	2.546666	2.546789	2.546913	2.547036	123
353	2.547775	2.547898	2.548021	2.548144	2.548266	123
354	2.549003	2.549126	2.549249	2.549371	2.549494	123
355	2.550228	2.550351	2.550473	2.550595	2.550717	122
356	2.551450	2.551572	2.551694	2.551816	2.551938	122
357	2.552668	2.552790	2.552911	2.553033	2.553154	121

Num	5	0	7	8	9	Diff.
315	2.498499	2.499137	2.499275	2.499412	2.499550	138
316	2.500374	2.500511	2.500648	2.500785	2.500922	137
317	2.501744	2.501880	2.502017	2.502154	2.502290	137
318	2.503109	2.503246	2.503382	2.503518	2.503654	136
319	2.504771	2.504607	2.504743	2.504878	2.505014	136
320	2.505828	2.505963	2.506099	2.506234	2.506370	136
321	2.507181	2.507316	2.507451	2.507586	2.507721	135
322	2.508530	2.508664	2.508799	2.508933	2.509068	135
323	2.509874	2.510008	2.510143	2.510277	2.510411	134
324	2.511215	2.511348	2.511482	2.511616	2.511750	134
325	2.512551	2.512684	2.512818	2.512951	2.513084	133
326	2.513883	2.514016	2.514149	2.514282	2.514415	133
327	2.515211	2.515344	2.515476	2.515609	2.515741	133
328	2.516535	2.516668	2.516800	2.516932	2.517064	132
329	2.517855	2.517987	2.518119	2.518251	2.518382	132
330	2.519171	2.519303	2.519434	2.519565	2.519697	132
331	2.520483	2.520614	2.520745	2.520876	2.521007	131
332	2.521792	2.521922	2.522053	2.522183	2.522314	131
333	2.523096	2.523226	2.523356	2.523486	2.523616	130
334	2.524396	2.524526	2.524656	2.524785	2.524915	130
335	2.525692	2.525822	2.525951	2.526081	2.526210	129
336	2.526985	2.527114	2.527243	2.527372	2.527501	129
337	2.528274	2.528402	2.528531	2.528660	2.528788	129
338	2.529559	2.529687	2.529815	2.529943	2.530072	128
339	2.530840	2.530968	2.531095	2.531223	2.531351	128
340	2.532117	2.532245	2.532372	2.532500	2.532627	128
341	2.533391	2.533518	2.533645	2.533772	2.533899	127
342	2.534661	2.534787	2.534914	2.535041	2.535167	127
343	2.535927	2.536053	2.536179	2.536306	2.536432	126
344	2.537189	2.537315	2.537441	2.537567	2.537693	126
345	2.538448	2.538574	2.538699	2.538825	2.538951	126
346	2.539703	2.539829	2.539954	2.540079	2.540204	125
347	2.540955	2.541080	2.541205	2.541330	2.541454	125
348	2.542203	2.542327	2.542452	2.542576	2.542701	125
349	2.543447	2.543571	2.543696	2.543820	2.543944	124
350	2.544688	2.544812	2.544936	2.545060	2.545183	124
351	2.545925	2.546049	2.546172	2.546296	2.546419	124
352	2.547159	2.547282	2.547405	2.547529	2.547652	123
353	2.548389	2.548512	2.548635	2.548758	2.548881	123
354	2.549616	2.549739	2.549861	2.549984	2.550106	123
355	2.550840	2.550962	2.551084	2.551206	2.551328	122
356	2.552059	2.552181	2.552303	2.552425	2.552546	122
357	2.553276	2.553397	2.553519	2.553640	2.553762	121

Num	0	1	2	3	4	Diff.
358	2.553883	2.554004	2.554126	2.554247	2.554368	121
359	2.555094	2.555215	2.555336	2.555457	2.555578	121
360	2.556302	2.556423	2.556544	2.556664	2.556785	121
361	2.557507	2.557627	2.557748	2.557868	2.557988	120
362	2.558709	2.558828	2.558948	2.559068	2.559188	120
363	2.559907	2.560026	2.560146	2.560265	2.560385	120
364	2.561101	2.561221	2.561340	2.561459	2.561578	119
365	2.562295	2.562412	2.562531	2.562650	2.562768	119
566	2.563481	2.563600	2.563718	2.563837	2.563955	119
367	2.564666	2.564784	2.564903	2.565021	2.565139	118
368	2.565848	2.565966	2.566084	2.566202	2.566320	118
369	2.567026	2.567144	2.567262	2.567379	2.567497	118
370	2.568202	2.568319	2.568436	2.568554	2.568671	117
371	2.569374	2.569491	2.569608	2.569725	2.569842	117
372	2.570543	2.570660	2.570776	2.570893	2.571010	117
373	2.571709	2.571825	2.571942	2.572058	2.572174	116
374	2.572872	2.572988	2.573104	2.573220	2.573336	116
375	2.574031	2.574147	2.574263	2.574379	2.574494	116
376	2.575188	2.575303	2.575419	2.575534	2.575650	115
377	2.576341	2.576456	2.576572	2.576687	2.576802	115
378	2.577492	2.577607	2.577721	2.577836	2.577951	115
379	2.578639	2.578754	2.578868	2.578983	2.579097	114
380	2.579784	2.579898	2.580012	2.580126	2.580240	114
381	2.580925	2.581039	2.581153	2.581267	2.581381	114
382	2.582063	2.582177	2.582291	2.582404	2.582518	114
383	2.583199	2.583312	2.583425	2.583539	2.583652	113
384	2.584331	2.584444	2.584557	2.584670	2.584783	113
385	2.585461	2.585573	2.585686	2.585799	2.585912	113
386	2.586587	2.586700	2.586812	2.586925	2.587037	112
387	2.587711	2.587823	2.587935	2.588047	2.588160	112
388	2.588832	2.588944	2.589055	2.589167	2.589279	112
389	2.589950	2.590061	2.590173	2.590284	2.590396	112
390	2.591065	2.591176	2.591287	2.591398	2.591510	111
391	2.592177	2.592288	2.592399	2.592510	2.592621	111
392	2.593286	2.593397	2.593508	2.593618	2.593729	111
393	2.594392	2.594503	2.594613	2.594724	2.594834	110
394	2.595496	2.595606	2.595717	2.595827	2.595937	110
395	2.596597	2.596707	2.596817	2.596927	2.597037	110
396	2.597635	2.597805	2.597914	2.598024	2.598134	110
397	2.598790	2.598900	2.599009	2.599119	2.599228	109
398	2.599883	2.599992	2.600101	2.600210	2.600319	109
399	2.600973	2.601082	2.601190	2.601299	2.601408	109
400	2.602060	2.602168	2.602277	2.602386	2.602494	108

Num.	5	6	7	8	9	Dif.
358	2.554489	2.554610	2.554731	2.554852	2.554973	121
359	2.555699	2.555820	2.555940	2.556061	2.556182	121
360	2.556905	2.557026	2.557146	2.557266	2.557387	121
361	2.558108	2.558228	2.558348	2.558469	2.558589	120
362	2.559308	2.559428	2.559548	2.559667	2.559787	120
363	2.560504	2.560624	2.560743	2.560863	2.560982	119
364	2.561697	2.561817	2.561936	2.562055	2.562174	119
365	2.562887	2.563006	2.563125	2.563244	2.563362	119
366	2.564074	2.564192	2.564311	2.564429	2.564548	119
367	2.565257	2.565375	2.565494	2.565612	2.565730	118
368	2.566437	2.566555	2.566673	2.566791	2.566909	118
369	2.567614	2.567732	2.567849	2.567967	2.568084	118
370	2.568788	2.568905	2.569023	2.569140	2.569257	117
371	2.569959	2.570076	2.570193	2.570309	2.570426	117
372	2.571126	2.571243	2.571359	2.571476	2.571592	117
373	2.572291	2.572407	2.572523	2.572639	2.572755	116
374	2.573452	2.573568	2.573684	2.573800	2.573915	116
375	2.574610	2.574726	2.574841	2.574957	2.575072	116
376	2.575765	2.575880	2.575996	2.576111	2.576226	115
377	2.576917	2.577032	2.577147	2.577262	2.577377	115
378	2.578066	2.578181	2.578295	2.578410	2.578525	115
379	2.579212	2.579326	2.579441	2.579555	2.579669	114
380	2.580355	2.580469	2.580583	2.580697	2.580811	114
381	2.581495	2.581608	2.581722	2.581836	2.581950	114
382	2.582631	2.582745	2.582858	2.582972	2.583085	114
383	2.583765	2.583879	2.583992	2.584105	2.584218	113
384	2.584896	2.585009	2.585122	2.585235	2.585348	113
385	2.586024	2.586137	2.586250	2.586362	2.586475	113
386	2.587149	2.587262	2.587374	2.587486	2.587599	112
387	2.588272	2.588384	2.588496	2.588608	2.588720	112
388	2.589391	2.589503	2.589614	2.589726	2.589838	112
389	2.590507	2.590619	2.590730	2.590842	2.590953	112
390	2.591621	2.591732	2.591843	2.591955	2.592066	111
391	2.592732	2.592843	2.592954	2.593064	2.593175	111
392	2.593840	2.593950	2.594061	2.594171	2.594282	111
393	2.594945	2.595055	2.595165	2.595276	2.595386	110
394	2.596047	2.596157	2.596267	2.596377	2.596487	110
395	2.597146	2.597256	2.597366	2.597476	2.597585	110
396	2.598243	2.598353	2.598462	2.598572	2.598681	110
397	2.599337	2.599446	2.599556	2.599665	2.599774	109
398	2.600428	2.600537	2.600646	2.600755	2.600864	109
399	2.601517	2.601625	2.601734	2.601843	2.601951	109
400	2.602602	2.602711	2.602819	2.602928	2.603036	108

Num.	0	1	2	3	4	Diff.
401	2.603144	2.603253	2.603361	2.603469	2.603577	108
402	2.604226	2.604334	2.604442	2.604550	2.604658	108
403	2.605305	2.605413	2.605520	2.605628	2.605736	108
404	2.606381	2.606489	2.606596	2.606704	2.606811	107
405	2.607455	2.607562	2.607669	2.607777	2.607884	107
406	2.608526	2.608633	2.608740	2.608847	2.608954	107
407	2.609594	2.609701	2.609808	2.609914	2.610021	107
408	2.610660	2.610767	2.610873	2.610979	2.611086	106
409	2.611723	2.611829	2.611936	2.612042	2.612148	106
410	2.612784	2.612890	2.612996	2.613102	2.613209	106
411	2.613842	2.613947	2.614053	2.614159	2.614264	106
412	2.614897	2.615003	2.615108	2.615213	2.615319	105
413	2.615950	2.616055	2.616160	2.616265	2.616370	105
414	2.617000	2.617105	2.617210	2.617315	2.617420	105
415	2.618048	2.618153	2.618257	2.618362	2.618466	105
416	2.619093	2.619198	2.619302	2.619406	2.619511	104
417	2.620136	2.620240	2.620344	2.620448	2.620552	104
418	2.621176	2.621280	2.621384	2.621488	2.621592	104
419	2.622214	2.622318	2.622421	2.622525	2.622628	104
420	2.623249	2.623353	2.623456	2.623559	2.623663	103
421	2.624282	2.624385	2.624488	2.624591	2.624694	103
422	2.625312	2.625415	2.625518	2.625621	2.625724	103
423	2.626340	2.626443	2.626546	2.626648	2.626751	103
424	2.627366	2.627468	2.627571	2.627673	2.627775	102
425	2.628389	2.628491	2.628593	2.628695	2.628797	102
426	2.629410	2.629511	2.629613	2.629715	2.629817	102
427	2.630428	2.630529	2.630631	2.630733	2.630834	102
428	2.631444	2.631545	2.631647	2.631748	2.631849	101
429	2.632457	2.632558	2.632660	2.632761	2.632862	101
430	2.633468	2.633569	2.633670	2.633771	2.633872	101
431	2.634477	2.634578	2.634679	2.634779	2.634880	100
432	2.635484	2.635584	2.635685	2.635785	2.635886	100
433	2.636488	2.636588	2.636688	2.636789	2.636889	100
434	2.637490	2.637590	2.637690	2.637790	2.637890	100
435	2.638489	2.638589	2.638689	2.638789	2.638888	99
436	2.639485	2.639586	2.639686	2.639785	2.639885	99
437	2.640481	2.640581	2.640680	2.640779	2.640879	99
438	2.641474	2.641573	2.641672	2.641771	2.641870	99
439	2.642464	2.642563	2.642662	2.642761	2.642860	99
440	2.643453	2.643551	2.643650	2.643749	2.643847	98
441	2.644439	2.644537	2.644635	2.644734	2.644832	98
442	2.645422	2.645520	2.645619	2.645717	2.645815	98
443	2.646404	2.646502	2.646600	2.646698	2.646796	98

Num	5	6	7	8	9	Diff
401	2.603685	2.603794	2.603902	2.604010	2.604118	106
402	2.604766	2.604874	2.604982	2.605089	2.605197	108
403	2.605843	2.605951	2.606059	2.606166	2.606274	108
404	2.606918	2.607026	2.607133	2.607240	2.607348	107
405	2.607991	2.608098	2.608205	2.608312	2.608419	107
406	2.609060	2.609167	2.609274	2.609381	2.609488	107
407	2.610128	2.610244	2.610341	2.610447	2.610554	107
408	2.611192	2.611298	2.611405	2.611511	2.611617	106
409	2.612254	2.612360	2.612466	2.612572	2.612678	106
410	2.613313	2.613419	2.613525	2.613630	2.613736	106
411	2.614370	2.614475	2.614581	2.614686	2.614792	106
412	2.615424	2.615529	2.615634	2.615740	2.615845	105
413	2.616475	2.616580	2.616685	2.616790	2.616895	105
414	2.617524	2.617629	2.617734	2.617839	2.617943	105
415	2.618571	2.618675	2.618780	2.618884	2.618989	105
416	2.619615	2.619719	2.619823	2.619928	2.620032	104
417	2.620656	2.620760	2.620864	2.620968	2.621072	104
418	2.621695	2.621799	2.621903	2.622007	2.622110	104
419	2.622732	2.622835	2.622939	2.623042	2.623146	104
420	2.623766	2.623869	2.623972	2.624076	2.624179	103
421	2.624798	2.624901	2.625004	2.625107	2.625209	103
422	2.625827	2.625929	2.626032	2.626135	2.626238	103
423	2.626853	2.626956	2.627058	2.627161	2.627263	103
424	2.627878	2.627980	2.628082	2.628184	2.628287	102
424	2.628900	2.629002	2.629104	2.629206	2.629308	102
426	2.629919	2.630021	2.630123	2.630224	2.630326	102
427	2.630936	2.631038	2.631139	2.631241	2.631342	102
428	2.631951	2.632052	2.632153	2.632255	2.632356	101
429	2.632963	2.633064	2.633165	2.633266	2.633367	101
430	2.633973	2.634074	2.634175	2.634276	2.634376	100
431	2.634981	2.635081	2.635182	2.635283	2.635383	100
432	2.635986	2.636086	2.636187	2.636287	2.636388	100
433	2.636989	2.637089	2.637189	2.637289	2.637390	100
434	2.637980	2.638090	2.638190	2.638289	2.638389	99
435	2.638988	2.639088	2.639188	2.639287	2.639387	99
436	2.639984	2.640084	2.640183	2.640283	2.640382	99
437	2.640978	2.641077	2.641176	2.641276	2.641375	99
438	2.641970	2.642069	2.642168	2.642267	2.642366	99
439	2.642959	2.643058	2.643156	2.643255	2.643354	99
440	2.643946	2.644044	2.644143	2.644242	2.644340	98
441	2.644931	2.645029	2.645127	2.645226	2.645324	98
442	2.645913	2.646011	2.646109	2.646208	2.646306	98
443	2.646894	2.646991	2.647089	2.647187	2.647285	98

Num.	0	1	2	3	4	5
444	2.647383	2.647481	2.647578	2.647676	2.647774	98
445	2.648360	2.648458	2.648555	2.648653	2.648750	97
446	2.649335	2.649432	2.649530	2.649627	2.649724	97
447	2.650307	2.650405	2.650502	2.650599	2.650696	97
448	2.651278	2.651375	2.651472	2.651569	2.651666	97
449	2.652246	2.652343	2.652440	2.652536	2.652633	97
450	2.653212	2.653309	2.653405	2.653502	2.653598	96
451	2.654176	2.654273	2.654369	2.654465	2.654562	96
452	2.655138	2.655234	2.655331	2.655427	2.655523	96
453	2.656099	2.656194	2.656290	2.656386	2.656481	96
454	2.657056	2.657151	2.657247	2.657343	2.657438	96
455	2.658011	2.658107	2.658202	2.658298	2.658393	95
456	2.658965	2.659060	2.659155	2.659250	2.659346	95
457	2.659916	2.660011	2.660106	2.660201	2.660296	95
458	2.660865	2.660960	2.661055	2.661150	2.661245	95
459	2.661813	2.661907	2.662002	2.662096	2.662191	95
460	2.662758	2.662852	2.662947	2.663041	2.663135	94
461	2.663701	2.663795	2.663889	2.663983	2.664078	94
462	2.664642	2.664736	2.664830	2.664924	2.665018	94
463	2.665581	2.665675	2.665768	2.665862	2.665956	94
464	2.666518	2.666612	2.666705	2.666799	2.666892	94
465	2.667453	2.667546	2.667640	2.667733	2.667826	93
466	2.668386	2.668479	2.668572	2.668665	2.668758	93
467	2.669317	2.669410	2.669503	2.669596	2.669689	93
468	2.670246	2.670339	2.670431	2.670524	2.670617	93
469	2.671173	2.671265	2.671358	2.671451	2.671543	93
470	2.672098	2.672190	2.672283	2.672375	2.672467	92
471	2.673021	2.673113	2.673205	2.673297	2.673390	92
472	2.673942	2.674034	2.674126	2.674218	2.674310	92
473	2.674861	2.674953	2.675045	2.675136	2.675228	92
474	2.675778	2.675870	2.675961	2.676053	2.676145	92
475	2.676694	2.676785	2.676876	2.676968	2.677059	91
476	2.677607	2.677698	2.677789	2.677881	2.677972	91
477	2.678518	2.678609	2.678700	2.678791	2.678882	91
478	2.679428	2.679519	2.679610	2.679700	2.679791	91
479	2.680335	2.680426	2.680517	2.680607	2.680698	91
480	2.681241	2.681332	2.681422	2.681513	2.681603	90
481	2.682145	2.682235	2.682326	2.682416	2.682506	90
482	2.683047	2.683137	2.683227	2.683317	2.683407	90
483	2.683947	2.684037	2.684127	2.684217	2.684307	90
484	2.684845	2.684935	2.685025	2.685114	2.685204	90
485	2.685742	2.685831	2.685921	2.686010	2.686100	89
486	2.686636	2.686726	2.686815	2.686904	2.686994	89

Num.	5	6	7	8	9	Diff.
444	2.647872	2.647969	2.648007	2.648165	2.648262	98
445	2.648848	2.648945	2.649043	2.649140	2.649237	97
446	2.649821	2.649919	2.650016	2.650113	2.650210	97
447	2.650793	2.650890	2.650987	2.651084	2.651181	97
448	2.651762	2.651859	2.651956	2.652053	2.652150	97
449	2.652730	2.652826	2.652923	2.653019	2.653116	97
450	2.653695	2.653791	2.653888	2.653984	2.654080	96
451	2.654658	2.654754	2.654850	2.654946	2.655042	96
452	2.655619	2.655714	2.655810	2.655906	2.656002	96
453	2.656577	2.656673	2.656769	2.656864	2.656960	96
454	2.657534	2.657629	2.657725	2.657820	2.657916	96
455	2.658488	2.658584	2.658679	2.658774	2.658870	95
456	2.659441	2.659536	2.659631	2.659726	2.659821	95
457	2.660391	2.660486	2.660581	2.660676	2.660771	95
458	2.661339	2.661434	2.661529	2.661623	2.661718	95
459	2.662285	2.662380	2.662474	2.662569	2.662663	95
460	2.663230	2.663324	2.663418	2.663512	2.663607	94
461	2.664172	2.664266	2.664360	2.664454	2.664548	94
462	2.665112	2.665206	2.665299	2.665393	2.665487	94
463	2.666050	2.666143	2.666237	2.666331	2.666424	94
464	2.666986	2.667079	2.667173	2.667266	2.667359	94
465	2.667920	2.668013	2.668106	2.668199	2.668293	93
466	2.668852	2.668945	2.669038	2.669131	2.669224	93
467	2.669782	2.669874	2.669967	2.670060	2.670153	93
468	2.670710	2.670802	2.670895	2.670988	2.671080	93
469	2.671636	2.671728	2.671821	2.671913	2.672005	93
470	2.672560	2.672652	2.672744	2.672836	2.672929	92
471	2.673482	2.673574	2.673666	2.673758	2.673850	92
472	2.674402	2.674494	2.674586	2.674677	2.674769	92
473	2.675320	2.675412	2.675503	2.675595	2.675687	92
474	2.676236	2.676328	2.676419	2.676511	2.676602	92
475	2.677150	2.677242	2.677333	2.677424	2.677516	91
476	2.678063	2.678154	2.678245	2.678336	2.678427	91
477	2.678973	2.679064	2.679155	2.679246	2.679337	91
478	2.679882	2.679973	2.680063	2.680154	2.680245	91
479	2.680789	2.680879	2.680970	2.681060	2.681151	91
480	2.681693	2.681784	2.681874	2.681964	2.682055	90
481	2.682596	2.682686	2.682777	2.682867	2.682957	90
482	2.683497	2.683587	2.683677	2.683767	2.683857	90
483	2.684396	2.684486	2.684576	2.684666	2.684756	90
484	2.685294	2.685383	2.685473	2.685563	2.685652	90
485	2.686189	2.686279	2.686368	2.686457	2.686547	89
486	2.687083	2.687172	2.687261	2.687351	2.687440	89

(334) A Table of Logarithms,

Num.	0	1	2	3	4	Diff.
487	2.687529	2.687018	2.687707	2.687796	2.687885	89
488	2.688420	2.688509	2.688598	2.688687	2.688776	89
489	2.689309	2.689398	2.689486	2.689575	2.689664	89
490	2.690196	2.690285	2.690373	2.690462	2.690550	89
491	2.691081	2.691170	2.691258	2.691347	2.691435	88
492	2.691965	2.692053	2.692142	2.692230	2.692318	88
493	2.692847	2.692935	2.693023	2.693111	2.693199	88
494	2.693727	2.693815	2.693903	2.693991	2.694078	88
495	2.694605	2.694693	2.694781	2.694868	2.694956	88
496	2.695482	2.695569	2.695657	2.695744	2.695832	87
497	2.696356	2.696444	2.696531	2.696618	2.696706	87
498	2.697229	2.697316	2.697404	2.697491	2.697578	87
499	2.698100	2.698188	2.698275	2.698362	2.698448	87
500	2.698970	2.699057	2.699144	2.699230	2.699317	87
501	2.699838	2.699924	2.700011	2.700098	2.700184	87
502	2.700704	2.700790	2.700877	2.700963	2.701050	86
503	2.701568	2.701654	2.701741	2.701827	2.701913	86
504	2.702430	2.702517	2.702603	2.702689	2.702775	86
505	2.703291	2.703377	2.703463	2.703549	2.703635	86
506	2.704150	2.704236	2.704322	2.704408	2.704494	86
507	2.705008	2.705094	2.705179	2.705265	2.705350	86
508	2.705864	2.705949	2.706035	2.706120	2.706205	85
509	2.706718	2.706803	2.706888	2.706974	2.707059	85
510	2.707570	2.707655	2.707740	2.707826	2.707911	85
511	2.708421	2.708506	2.708591	2.708676	2.708761	85
512	2.709270	2.709355	2.709440	2.709524	2.709609	85
513	2.710117	2.710202	2.710287	2.710371	2.710456	85
514	2.710963	2.711048	2.711132	2.711216	2.711301	84
515	2.711807	2.711891	2.711976	2.712060	2.712144	84
516	2.712650	2.712734	2.712818	2.712902	2.712986	84
517	2.713490	2.713574	2.713658	2.713742	2.713826	84
518	2.714330	2.714414	2.714497	2.714581	2.714665	84
519	2.715167	2.715251	2.715335	2.715418	2.715502	84
520	2.716003	2.716087	2.716170	2.716254	2.716337	83
521	2.716838	2.716921	2.717004	2.717088	2.717171	83
522	2.717670	2.717754	2.717837	2.717920	2.718003	83
523	2.718502	2.718585	2.718668	2.718751	2.718834	83
524	2.719331	2.719414	2.719497	2.719580	2.719663	83
525	2.720159	2.720242	2.720325	2.720407	2.720490	83
526	2.720980	2.721068	2.721151	2.721233	2.721316	82
527	2.721811	2.721893	2.721975	2.722058	2.722140	82
528	2.722634	2.722716	2.722798	2.722881	2.722963	82
529	2.723456	2.723538	2.723620	2.723702	2.723784	82

from 1 to 10000.

(335)

Num	5	6	7	8	9	Diff.
487	2.687975	2.688064	2.688153	2.688242	2.688331	89
488	2.688365	2.688953	2.689042	2.689131	2.689220	89
489	2.689753	2.689841	2.689930	2.690019	2.690107	89
490	2.690639	2.690727	2.690816	2.690905	2.690993	89
491	2.691523	2.691612	2.691700	2.691788	2.691877	88
492	2.692406	2.692494	2.692583	2.692671	2.692759	88
493	2.693287	2.693375	2.693463	2.693551	2.693639	88
494	2.694166	2.694254	2.694342	2.694430	2.694517	88
495	2.695044	2.695131	2.695219	2.695306	2.695394	88
496	2.695919	2.696007	2.696094	2.696182	2.696269	87
497	2.696793	2.696880	2.696968	2.697055	2.697142	87
498	2.697665	2.697752	2.697839	2.697926	2.698013	87
499	2.698535	2.698622	2.698709	2.698796	2.698883	87
500	2.699404	2.699491	2.699578	2.699664	2.699751	87
501	2.700271	2.700357	2.700444	2.700531	2.700617	87
502	2.701136	2.701222	2.701309	2.701395	2.701482	86
503	2.701999	2.702086	2.702172	2.702258	2.702344	86
504	2.702861	2.702947	2.703033	2.703119	2.703205	86
505	2.703721	2.703807	2.703893	2.703979	2.704065	86
506	2.704579	2.704665	2.704751	2.704837	2.704922	86
507	2.705436	2.705522	2.705607	2.705693	2.705778	86
508	2.706291	2.706376	2.706462	2.706547	2.706632	85
509	2.707144	2.707229	2.707315	2.707400	2.707485	85
510	2.707996	2.708081	2.708166	2.708251	2.708336	85
511	2.708846	2.708931	2.709015	2.709100	2.709185	85
512	2.709694	2.709779	2.709863	2.709948	2.710033	85
513	2.710540	2.710625	2.710710	2.710794	2.710879	84
514	2.711385	2.711470	2.711554	2.711638	2.711723	84
515	2.712229	2.712313	2.712397	2.712481	2.712565	84
516	2.713070	2.713154	2.713238	2.713322	2.713406	84
517	2.713910	2.713994	2.714078	2.714162	2.714246	84
518	2.714749	2.714832	2.714916	2.715000	2.715084	84
519	2.715586	2.715669	2.715753	2.715836	2.715920	84
520	2.716421	2.716504	2.716588	2.716671	2.716754	83
521	2.717254	2.717338	2.717421	2.717504	2.717587	83
522	2.718086	2.718169	2.718253	2.718336	2.718419	83
523	2.718917	2.719000	2.719083	2.719165	2.719248	83
524	2.719745	2.719828	2.719911	2.719994	2.720077	83
525	2.720573	2.720655	2.720738	2.720821	2.720903	82
526	2.721398	2.721481	2.721563	2.721646	2.721728	82
527	2.722242	2.722325	2.722407	2.722489	2.722572	82
528	2.723045	2.723127	2.723209	2.723291	2.723374	82
529	2.723866	2.723948	2.724030	2.724112	2.724194	82

Num.	0	1	2	3	4	Diff.
530	2.724276	2.724358	2.724440	2.724522	2.724603	82
531	2.725094	2.725176	2.725258	2.725340	2.725421	82
532	2.725912	2.725993	2.726075	2.726156	2.726238	82
533	2.726727	2.726809	2.726890	2.726972	2.727053	81
534	2.727541	2.727623	2.727704	2.727785	2.727866	81
535	2.728354	2.728435	2.728516	2.728597	2.728678	81
536	2.729165	2.729246	2.729327	2.729408	2.729489	81
537	2.729974	2.730055	2.730136	2.730217	2.730298	81
538	2.730782	2.730863	2.730944	2.731024	2.731105	81
539	2.731589	2.731669	2.731750	2.731830	2.731911	81
540	2.732394	2.732474	2.732555	2.732635	2.732715	80
541	2.733197	2.733277	2.733358	2.733438	2.733518	80
542	2.733999	2.734079	2.734159	2.734240	2.734320	80
543	2.734800	2.734880	2.734960	2.735040	2.735120	80
544	2.735599	2.735679	2.735758	2.735838	2.735918	80
545	2.736396	2.736476	2.736556	2.736635	2.736715	80
546	2.737193	2.737272	2.737352	2.737431	2.737511	79
547	2.737987	2.738067	2.738146	2.738225	2.738305	79
548	2.738781	2.738860	2.738939	2.739018	2.739097	79
549	2.739572	2.739651	2.739730	2.739810	2.739889	79
550	2.740363	2.740442	2.740521	2.740599	2.740678	79
551	2.741152	2.741230	2.741309	2.741388	2.741467	79
552	2.741939	2.742018	2.742096	2.742175	2.742254	79
553	2.742725	2.742804	2.742882	2.742961	2.743039	78
554	2.743510	2.743588	2.743666	2.743745	2.743823	78
555	2.744293	2.744371	2.744449	2.744528	2.744606	78
556	2.745075	2.745153	2.745231	2.745309	2.745387	78
557	2.745855	2.745933	2.746011	2.746089	2.746167	78
558	2.746634	2.746712	2.746790	2.746868	2.746945	78
559	2.747412	2.747489	2.747567	2.747645	2.747722	78
560	2.748188	2.748266	2.748343	2.748421	2.748498	77
561	2.748963	2.749040	2.749118	2.749195	2.749272	77
562	2.749736	2.749814	2.749891	2.749968	2.750045	77
563	2.750508	2.750586	2.750663	2.750740	2.750817	77
564	2.751279	2.751356	2.751433	2.751510	2.751587	77
565	2.752048	2.752125	2.752202	2.752279	2.752356	77
566	2.752816	2.752893	2.752970	2.753047	2.753123	77
567	2.753583	2.753660	2.753736	2.753813	2.753889	77
568	2.754348	2.754425	2.754501	2.754578	2.754654	77
569	2.755112	2.755189	2.755265	2.755341	2.755417	76
570	2.755875	2.755951	2.756027	2.756103	2.756180	76
571	2.756626	2.756702	2.756778	2.756854	2.756930	76
572	2.757396	2.757472	2.757548	2.757624	2.757700	76

Num.	5	6	7	8	9	Diff
530	2.724085	2.724767	2.724849	2.724931	2.725013	82
531	2.725503	2.725585	2.725667	2.725748	2.725830	82
532	2.726320	2.726401	2.726483	2.726564	2.726646	82
533	2.727134	2.727216	2.727297	2.727379	2.727460	81
534	2.727948	2.728029	2.728110	2.728191	2.728273	81
535	2.728759	2.728841	2.728922	2.729003	2.729084	81
536	2.729570	2.729651	2.729732	2.729813	2.729893	81
537	2.730378	2.730459	2.730540	2.730621	2.730702	81
538	2.731186	2.731266	2.731347	2.731428	2.731508	81
539	2.731991	2.732072	2.732152	2.732233	2.732313	81
540	2.732796	2.732876	2.732956	2.733037	2.733117	80
541	2.733598	2.733679	2.733759	2.733839	2.733919	80
542	2.734400	2.734480	2.734560	2.734640	2.734720	80
543	2.735200	2.735279	2.735359	2.735439	2.735519	80
544	2.735998	2.736078	2.736157	2.736237	2.736317	80
545	2.736795	2.736874	2.736954	2.737034	2.737113	80
546	2.737590	2.737670	2.737749	2.737829	2.737908	79
547	2.738384	2.738463	2.738543	2.738622	2.738701	79
548	2.739177	2.739256	2.739335	2.739414	2.739493	79
549	2.739968	2.740047	2.740126	2.740205	2.740284	79
550	2.740757	2.740836	2.740915	2.740994	2.741073	79
551	2.741546	2.741624	2.741703	2.741782	2.741860	79
552	2.742333	2.742411	2.742489	2.742568	2.742647	79
553	2.743118	2.743196	2.743275	2.743353	2.743431	78
554	2.743902	2.743980	2.744058	2.744136	2.744215	78
555	2.744684	2.744762	2.744840	2.744919	2.744997	78
556	2.745465	2.745543	2.745621	2.745699	2.745777	78
557	2.746245	2.746323	2.746401	2.746479	2.746556	78
558	2.747023	2.747101	2.747179	2.747256	2.747334	78
559	2.747800	2.747878	2.747955	2.748033	2.748110	78
560	2.748576	2.748653	2.748731	2.748808	2.748885	77
561	2.749350	2.749427	2.749504	2.749582	2.749659	77
562	2.750123	2.750200	2.750277	2.750354	2.750431	77
563	2.750894	2.750971	2.751048	2.751125	2.751202	77
564	2.751664	2.751741	2.751818	2.751895	2.751972	77
565	2.752433	2.752509	2.752586	2.752663	2.752740	77
566	2.753200	2.753277	2.753353	2.753430	2.753506	77
567	2.753966	2.754042	2.754119	2.754195	2.754272	77
568	2.754730	2.754807	2.754883	2.754960	2.755036	77
569	2.755494	2.755570	2.755646	2.755722	2.755799	76
570	2.756256	2.756332	2.756408	2.756484	2.756560	76
571	2.757016	2.757092	2.757168	2.757244	2.757320	76
572	2.757775	2.757851	2.757927	2.758003	2.758079	76

Num.	0	1	2	3	4	Diff.
573	2.758155	2.758230	2.758306	2.758382	2.758458	70
574	2.758912	2.758988	2.759063	2.759139	2.759214	76
575	2.759668	2.759743	2.759819	2.759894	2.759970	75
576	2.760422	2.760498	2.760573	2.760649	2.760724	75
577	2.761176	2.761251	2.761326	2.761402	2.761477	75
578	2.761928	2.762003	2.762078	2.762153	2.762228	75
579	2.762679	2.762754	2.762829	2.762904	2.762978	75
580	2.763428	2.763503	2.763578	2.763652	2.763727	75
581	2.764176	2.764251	2.764326	2.764400	2.764475	75
582	2.764923	2.764998	2.765072	2.765147	2.765221	75
583	2.765669	2.765743	2.765818	2.765892	2.765966	74
584	2.766413	2.766487	2.766562	2.766636	2.766710	74
585	2.767156	2.767230	2.767304	2.767379	2.767453	74
586	2.767898	2.767972	2.768046	2.768120	2.768194	74
587	2.768638	2.768712	2.768786	2.768860	2.768934	74
588	2.769377	2.769451	2.769525	2.769599	2.769673	74
589	2.770115	2.770189	2.770263	2.770336	2.770410	74
590	2.770852	2.770926	2.770999	2.771073	2.771146	74
591	2.771587	2.771661	2.771734	2.771808	2.771881	73
592	2.772322	2.772395	2.772468	2.772542	2.772615	73
593	2.773055	2.773128	2.773201	2.773274	2.773348	73
594	2.773786	2.773860	2.773933	2.774006	2.774079	73
595	2.774517	2.774590	2.774663	2.774736	2.774809	73
596	2.775246	2.775319	2.775392	2.775465	2.775538	73
597	2.775974	2.776047	2.776120	2.776193	2.776265	73
598	2.776701	2.776774	2.776846	2.776919	2.776992	73
599	2.777427	2.777499	2.777572	2.777644	2.777717	72
600	2.778151	2.778224	2.778296	2.778368	2.778441	72
601	2.778874	2.778947	2.779019	2.779091	2.779163	72
602	2.779596	2.779669	2.779741	2.779813	2.779885	72
603	2.780317	2.780389	2.780461	2.780533	2.780605	72
604	2.781037	2.781109	2.781181	2.781253	2.781324	72
605	2.781755	2.781827	2.781899	2.781971	2.782042	72
606	2.782473	2.782544	2.782616	2.782688	2.782759	72
607	2.783189	2.783260	2.783332	2.783403	2.783475	71
608	2.783904	2.783975	2.784046	2.784118	2.784189	71
609	2.784617	2.784689	2.784760	2.784831	2.784902	71
610	2.785330	2.785401	2.785472	2.785544	2.785615	71
611	2.786041	2.786112	2.786183	2.786254	2.786325	71
612	2.786751	2.786822	2.786893	2.786964	2.787035	71
613	2.787460	2.787531	2.787602	2.787673	2.787744	71
614	2.788168	2.788239	2.788310	2.788381	2.788451	71
615	2.788975	2.789046	2.789116	2.789187	2.789258	71

from 1 to 10000.

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Num.	5	6	7	8	9	Diff.
573	2.758533	2.758609	2.758685	2.758761	2.758836	76
574	2.759290	2.759366	2.759441	2.759517	2.759592	76
575	2.760045	2.760121	2.760196	2.760272	2.760347	75
576	2.760799	2.760875	2.760950	2.761025	2.761101	75
577	2.761552	2.761627	2.761702	2.761778	2.761853	75
578	2.762303	2.762378	2.762453	2.762529	2.762604	75
579	2.763053	2.763128	2.763203	2.763278	2.763353	75
580	2.763802	2.763877	2.763952	2.764027	2.764101	75
581	2.764550	2.764624	2.764699	2.764774	2.764848	75
582	2.765296	2.765370	2.765445	2.765520	2.765594	75
583	2.766041	2.766115	2.766190	2.766264	2.766338	74
584	2.766785	2.766859	2.766933	2.767007	2.767082	74
585	2.767527	2.767601	2.767675	2.767749	2.767823	74
586	2.768268	2.768342	2.768416	2.768490	2.768564	74
587	2.769008	2.769082	2.769156	2.769230	2.769303	74
588	2.769746	2.769820	2.769894	2.769968	2.770042	74
589	2.770484	2.770557	2.770631	2.770705	2.770778	74
590	2.771220	2.771293	2.771367	2.771440	2.771514	74
591	2.771955	2.772028	2.772102	2.772175	2.772248	73
592	2.772688	2.772762	2.772835	2.772909	2.772981	73
593	2.773421	2.773494	2.773567	2.773640	2.773713	73
594	2.774152	2.774225	2.774298	2.774371	2.774444	73
595	2.774882	2.774955	2.775028	2.775100	2.775173	73
596	2.775610	2.775683	2.775756	2.775829	2.775902	73
597	2.776338	2.776411	2.776483	2.776556	2.776629	73
598	2.777064	2.777137	2.777209	2.777282	2.777354	73
599	2.777789	2.777862	2.777934	2.778006	2.778079	72
600	2.778513	2.778585	2.778658	2.778730	2.778802	72
601	2.779236	2.779308	2.779380	2.779452	2.779524	72
602	2.779957	2.780029	2.780101	2.780173	2.780245	72
603	2.780677	2.780749	2.780821	2.780893	2.780965	72
604	2.781396	2.781468	2.781540	2.781612	2.781684	72
605	2.782114	2.782186	2.782258	2.782329	2.782401	72
606	2.782831	2.782902	2.782974	2.783046	2.783117	72
607	2.783546	2.783618	2.783689	2.783761	2.783832	71
608	2.784261	2.784332	2.784403	2.784475	2.784546	71
609	2.784974	2.785045	2.785116	2.785187	2.785259	71
610	2.785686	2.785757	2.785828	2.785899	2.785970	71
611	2.786396	2.786467	2.786538	2.786609	2.786680	71
612	2.787106	2.787177	2.787248	2.787319	2.787390	71
613	2.787815	2.787885	2.787956	2.788027	2.788098	71
614	2.788522	2.788593	2.788663	2.788734	2.788804	71
615	2.789228	2.789299	2.789369	2.789440	2.789510	71

Num.	0	1	2	3	4	Diff.
616	2.789581	2.789651	2.789722	2.789792	2.789863	70
617	2.790285	2.790356	2.790426	2.790496	2.790567	70
618	2.790989	2.791059	2.791129	2.791199	2.791269	70
619	2.791691	2.791761	2.791831	2.791901	2.791971	70
620	2.792392	2.792462	2.792532	2.792602	2.792672	70
621	2.793092	2.793162	2.793231	2.793301	2.793371	70
622	2.793790	2.793860	2.793930	2.794000	2.794070	70
623	2.794488	2.794558	2.794627	2.794697	2.794767	70
624	2.795185	2.795254	2.795324	2.795393	2.795463	69
625	2.795880	2.795949	2.796019	2.796088	2.796158	69
626	2.796574	2.796644	2.796713	2.796782	2.796852	69
627	2.797268	2.797337	2.797406	2.797475	2.797545	69
628	2.797960	2.798029	2.798098	2.798167	2.798237	69
629	2.798651	2.798720	2.798789	2.798858	2.798927	69
630	2.799341	2.799409	2.799478	2.799547	2.799616	69
631	2.800029	2.800098	2.800166	2.800236	2.800305	69
632	2.800717	2.800786	2.800854	2.800923	2.800992	69
633	2.801404	2.801472	2.801541	2.801609	2.801678	69
634	2.802089	2.802158	2.802226	2.802295	2.802363	68
635	2.802774	2.802842	2.802910	2.802979	2.803047	68
636	2.803457	2.803525	2.803594	2.803662	2.803730	68
637	2.804139	2.804208	2.804276	2.804344	2.804412	68
638	2.804821	2.804889	2.804957	2.805025	2.805093	68
639	2.805501	2.805569	2.805637	2.805705	2.805773	68
640	2.806180	2.806248	2.806316	2.806384	2.806451	68
641	2.806858	2.806926	2.806994	2.807061	2.807129	68
642	2.807535	2.807603	2.807670	2.807738	2.807806	68
643	2.808211	2.808279	2.808346	2.808414	2.808481	67
644	2.808886	2.808953	2.809021	2.809088	2.809155	67
645	2.809560	2.809627	2.809694	2.809762	2.809829	67
646	2.810233	2.810300	2.810367	2.810434	2.810501	67
647	2.810904	2.810971	2.811038	2.811106	2.811173	67
648	2.811575	2.811642	2.811709	2.811776	2.811843	67
649	2.812245	2.812312	2.812378	2.812445	2.812512	67
650	2.812913	2.812980	2.813047	2.813114	2.813180	67
651	2.813581	2.813648	2.813714	2.813781	2.813848	67
652	2.814248	2.814314	2.814381	2.814447	2.814514	67
653	2.814913	2.814980	2.815046	2.815113	2.815179	66
654	2.815578	2.815644	2.815710	2.815777	2.815843	66
655	2.816241	2.816308	2.816374	2.816440	2.816509	66
656	2.816904	2.816970	2.817036	2.817102	2.817169	66
657	2.817565	2.817631	2.817698	2.817764	2.817830	66
658	2.818226	2.818292	2.818358	2.818424	2.818490	66

from 1 to 10000.

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Num	5	6	7	8	9	Diff
616	2.789933	2.790003	2.790074	2.790144	2.790215	70
617	2.790037	2.790707	2.790778	2.790848	2.790918	70
618	2.791340	2.791410	2.791480	2.791550	2.791620	70
619	2.792041	2.792111	2.792181	2.792252	2.792322	70
620	2.792742	2.792812	2.792882	2.792952	2.793022	70
621	2.793441	2.793511	2.793581	2.793651	2.793721	70
622	2.794139	2.794209	2.794279	2.794349	2.794418	70
623	2.794836	2.794906	2.794976	2.795045	2.795115	70
624	2.795532	2.795602	2.795671	2.795741	2.795810	09
625	2.796227	2.796297	2.796366	2.796435	2.796505	69
626	2.796921	2.796990	2.797060	2.797129	2.797198	69
627	2.797614	2.797683	2.797752	2.797821	2.797890	69
628	2.798305	2.798374	2.798443	2.798512	2.798582	69
629	2.798996	2.799065	2.799134	2.799203	2.799272	69
630	2.799685	2.799754	2.799823	2.799892	2.799960	69
631	2.800373	2.800442	2.800511	2.800580	2.800648	69
632	2.801060	2.801129	2.801198	2.801267	2.801335	69
633	2.801747	2.801815	2.801884	2.801952	2.802021	69
634	2.802432	2.802500	2.802568	2.802637	2.802705	68
635	2.803116	2.803184	2.803252	2.803321	2.803389	68
636	2.803798	2.803867	2.803935	2.804003	2.804071	68
637	2.804480	2.804548	2.804616	2.804685	2.804753	68
638	2.805161	2.805229	2.805297	2.805365	2.805433	68
639	2.805840	2.805908	2.805976	2.806044	2.806112	68
640	2.806519	2.806587	2.806655	2.806723	2.806790	68
641	2.807197	2.807264	2.807332	2.807400	2.807467	68
642	2.807873	2.807941	2.808008	2.808076	2.808143	68
643	2.808548	2.808616	2.808683	2.808751	2.808818	67
644	2.809223	2.809290	2.809358	2.809425	2.809492	67
645	2.809896	2.809963	2.810031	2.810098	2.810165	67
646	2.810568	2.810636	2.810703	2.810770	2.810837	67
647	2.811240	2.811307	2.811374	2.811441	2.811508	67
648	2.811910	2.811977	2.812044	2.812111	2.812178	67
649	2.812579	2.812646	2.812713	2.812780	2.812846	67
650	2.813247	2.813314	2.813381	2.813447	2.813514	67
651	2.813914	2.813981	2.814048	2.814114	2.814181	67
652	2.814580	2.814647	2.814714	2.814780	2.814847	67
653	2.815246	2.815312	2.815378	2.815445	2.815511	66
654	2.815910	2.815976	2.816042	2.816109	2.816175	66
655	2.816573	2.816639	2.816705	2.816771	2.816838	66
656	2.817235	2.817301	2.817367	2.817433	2.817499	66
657	2.817896	2.817962	2.818028	2.818093	2.818160	66
658	2.818556	2.818622	2.818688	2.818754	2.818819	66

Nums.	0	1	2	3	4	Diff.
659	2.818885	2.818951	2.819017	2.819083	2.819149	66
660	2.819544	2.819610	2.819674	2.819741	2.819807	66
661	2.820201	2.820267	2.820333	2.820398	2.820464	66
662	2.820858	2.820924	2.820989	2.821055	2.821120	66
663	2.821513	2.821579	2.821644	2.821710	2.821775	65
664	2.822168	2.822233	2.822299	2.822364	2.822430	65
665	2.822822	2.822887	2.822952	2.823017	2.823083	65
666	2.823474	2.823539	2.823605	2.823670	2.823735	65
667	2.824126	2.824191	2.824256	2.824321	2.824386	65
668	2.824776	2.824841	2.824906	2.824971	2.825036	65
669	2.825426	2.825491	2.825556	2.825621	2.825686	65
670	2.826075	2.826140	2.826204	2.826269	2.826334	65
671	2.826722	2.826787	2.826852	2.826917	2.826981	65
672	2.827369	2.827434	2.827498	2.827563	2.827628	65
673	2.828015	2.828080	2.828144	2.828209	2.828273	64
674	2.828660	2.828724	2.828789	2.828853	2.828918	64
675	2.829304	2.829368	2.829432	2.829497	2.829561	64
676	2.829947	2.830011	2.830075	2.830139	2.830204	64
677	2.830589	2.830653	2.830717	2.830781	2.830845	64
678	2.831230	2.831294	2.831358	2.831422	2.831486	64
679	2.831870	2.831934	2.831998	2.832062	2.832125	64
680	2.832509	2.832573	2.832637	2.832700	2.832764	64
681	2.833147	2.833211	2.833275	2.833338	2.833402	64
682	2.833784	2.833848	2.833912	2.833975	2.834039	64
683	2.834421	2.834484	2.834548	2.834611	2.834675	64
684	2.835056	2.835120	2.835183	2.835246	2.835310	63
685	2.835691	2.835754	2.835817	2.835881	2.835944	63
686	2.836324	2.836387	2.836451	2.836514	2.836577	63
687	2.836957	2.837020	2.837083	2.837146	2.837209	63
688	2.837588	2.837652	2.837715	2.837778	2.837841	63
689	2.838219	2.838282	2.838345	2.838408	2.838471	63
990	2.838849	2.838912	2.838975	2.839038	2.839101	63
691	2.839478	2.839541	2.839604	2.839667	2.839729	63
692	2.840106	2.840169	2.840232	2.840294	2.840357	63
693	2.840733	2.840796	2.840859	2.840921	2.840984	63
694	2.841359	2.841422	2.841485	2.841547	2.841610	63
695	2.841985	2.842047	2.842110	2.842172	2.842235	62
696	2.842609	2.842672	2.842734	2.842796	2.842859	62
697	2.843233	2.843295	2.843357	2.843420	2.843482	62
698	2.843855	2.843918	2.843980	2.844042	2.844104	62
699	2.844477	2.844539	2.844601	2.844663	2.844726	62
700	2.845098	2.845160	2.845222	2.845284	2.845346	62
701	2.845718	2.845780	2.845842	2.845904	2.845966	62

from 1 to 10000.

(343)

Nums	5	6	7	8	9	Dif.
659	2.819215	2.819281	2.819346	2.819412	2.819478	66
660	2.819873	2.819939	2.820004	2.820070	2.820136	66
661	2.820530	2.820595	2.820661	2.820727	2.820792	66
662	2.821186	2.821251	2.821317	2.821382	2.821448	66
663	2.821844	2.821906	2.821972	2.822037	2.822103	65
664	2.822495	2.822560	2.822626	2.822691	2.822756	65
665	2.823148	2.823213	2.823279	2.823344	2.823409	65
666	2.823800	2.823865	2.823930	2.823996	2.824061	65
667	2.824451	2.824516	2.824581	2.824646	2.824711	65
668	2.825101	2.825166	2.825232	2.825296	2.825361	65
669	2.825751	2.825815	2.825880	2.825945	2.826010	65
670	2.826399	2.826464	2.826528	2.826593	2.826658	65
671	2.827046	2.827111	2.827175	2.827240	2.827305	65
672	2.827692	2.827757	2.827821	2.827886	2.827950	65
673	2.828338	2.828402	2.828467	2.828531	2.828595	64
674	2.828982	2.829046	2.829111	2.829175	2.829239	64
675	2.829625	2.829690	2.829754	2.829818	2.829882	64
676	2.830268	2.830332	2.830396	2.830460	2.830524	64
677	2.830909	2.830973	2.831037	2.831102	2.831166	64
678	2.831550	2.831614	2.831678	2.831742	2.831806	64
679	2.832189	2.832253	2.832317	2.832381	2.832445	64
680	2.832828	2.832892	2.832956	2.833019	2.833083	64
681	2.833466	2.833530	2.833593	2.833657	2.833721	64
682	2.834103	2.834166	2.834230	2.834293	2.834357	64
683	2.834738	2.834802	2.834866	2.834929	2.834993	64
684	2.835373	2.835437	2.835500	2.835564	2.835627	63
685	2.836007	2.836071	2.836134	2.836197	2.836261	63
686	2.836640	2.836704	2.836767	2.836830	2.836893	63
687	2.837273	2.837336	2.837399	2.837462	2.837525	63
688	2.837904	2.837967	2.838030	2.838093	2.838156	63
689	2.838534	2.838597	2.838660	2.838723	2.838786	63
690	2.839164	2.839227	2.839289	2.839352	2.839415	63
691	2.839792	2.839855	2.839918	2.839981	2.840043	63
692	2.840420	2.840482	2.840545	2.840608	2.840671	63
693	2.841046	2.841109	2.841172	2.841234	2.841297	63
694	2.841672	2.841735	2.841797	2.841860	2.841922	63
695	2.842297	2.842360	2.842422	2.842484	2.842547	62
696	2.842921	2.842983	2.843046	2.843108	2.843170	62
697	2.843544	2.843606	2.843669	2.843731	2.843793	62
698	2.844166	2.844229	2.844291	2.844353	2.844415	62
699	2.844788	2.844850	2.844912	2.844974	2.845036	62
700	2.845408	2.845470	2.845532	2.845594	2.845656	62
701	2.846028	2.846090	2.846151	2.846213	2.846275	62

Num.	0	1	2	3	4	Diff
702	2.846337	2.846399	2.846461	2.846523	2.846584	62
703	2.846955	2.847017	2.847079	2.847141	2.847202	62
704	2.847573	2.847634	2.847696	2.847758	2.847819	62
705	2.848189	2.848251	2.848312	2.848374	2.848435	62
706	2.848805	2.848866	2.848928	2.848989	2.849051	61
707	2.849419	2.849481	2.849542	2.849604	2.849665	61
708	2.850033	2.850095	2.850156	2.850217	2.850279	61
709	2.850646	2.850707	2.850769	2.850830	2.850891	61
710	2.851258	2.851319	2.851381	2.851442	2.851503	61
711	2.851870	2.851931	2.851992	2.852053	2.852114	61
712	2.852480	2.852541	2.852602	2.852663	2.852724	61
713	2.853089	2.853150	2.853211	2.853272	2.853333	61
714	2.853698	2.853759	2.853820	2.853881	2.853941	61
715	2.854306	2.854367	2.854427	2.854488	2.854549	61
716	2.854913	2.854974	2.855034	2.855095	2.855156	61
717	2.855519	2.855580	2.855640	2.855701	2.855761	60
718	2.856124	2.856185	2.856245	2.856306	2.856366	60
719	2.856729	2.856789	2.856850	2.856910	2.856970	60
720	2.857332	2.857393	2.857453	2.857513	2.857574	60
721	2.857955	2.857995	2.858056	2.858116	2.858176	60
722	2.858537	2.858597	2.858657	2.858718	2.858778	60
723	2.859138	2.859198	2.859258	2.859318	2.859378	60
724	2.859739	2.859798	2.859858	2.859918	2.859978	60
725	2.860338	2.860398	2.860458	2.860518	2.860578	60
726	2.860937	2.860996	2.861056	2.861116	2.861176	60
727	2.861534	2.861594	2.861654	2.861714	2.861773	60
728	2.862131	2.862191	2.862251	2.862310	2.862370	60
729	2.862727	2.862787	2.862847	2.862906	2.862966	60
730	2.863323	2.863382	2.863442	2.863501	2.863561	59
731	2.863917	2.863977	2.864036	2.864096	2.864155	59
732	2.864511	2.864570	2.864630	2.864689	2.864748	59
733	2.865104	2.865163	2.865222	2.865282	2.865341	59
734	2.865696	2.865755	2.865814	2.865873	2.865933	59
735	2.866287	2.866346	2.866405	2.866465	2.866524	59
736	2.866878	2.866937	2.866996	2.867055	2.867114	59
737	2.867467	2.867526	2.867585	2.867644	2.867703	59
738	2.868056	2.868115	2.868174	2.868233	2.868292	59
739	2.868644	2.868703	2.868762	2.868821	2.868879	59
740	2.869232	2.869290	2.869349	2.869408	2.869466	59
741	2.869818	2.869877	2.869935	2.869994	2.870053	59
742	2.870404	2.870462	2.870521	2.870579	2.870638	58
743	2.870989	2.871047	2.871106	2.871164	2.871223	58
744	2.871573	2.871631	2.871690	2.871748	2.871806	58

Num.	5	0	7	0	9	Diff.
702	2.846646	2.846708	2.846770	2.846832	2.846893	62
703	2.847264	2.847326	2.847388	2.847449	2.847511	62
704	2.847881	2.847943	2.848004	2.848066	2.848127	62
705	2.848497	2.848559	2.848620	2.848682	2.848743	62
706	2.849112	2.849174	2.849235	2.849296	2.849358	61
707	2.849726	2.849788	2.849849	2.849911	2.849972	61
708	2.850340	2.850401	2.850462	2.850524	2.850585	61
709	2.850952	2.851014	2.851075	2.851136	2.851197	61
710	2.851564	2.851625	2.851686	2.851747	2.851808	61
711	2.852175	2.852236	2.852297	2.852358	2.852419	61
712	2.852785	2.852846	2.852907	2.852968	2.853029	61
713	2.853394	2.853455	2.853516	2.853576	2.853637	61
714	2.854002	2.854063	2.854124	2.854184	2.854245	61
715	2.854610	2.854670	2.854731	2.854792	2.854852	61
716	2.855216	2.855277	2.855337	2.855398	2.855459	61
717	2.855822	2.855882	2.855943	2.856003	2.856064	60
718	2.856427	2.856487	2.856548	2.856608	2.856668	60
719	2.857031	2.857091	2.857151	2.857212	2.857272	60
720	2.857634	2.857694	2.857754	2.857815	2.857875	60
721	2.858236	2.858296	2.858357	2.858417	2.858477	60
722	2.858838	2.858898	2.858958	2.859018	2.859078	60
723	2.859438	2.859498	2.859559	2.859619	2.859679	60
724	2.860038	2.860098	2.860158	2.860218	2.860278	60
725	2.860637	2.860697	2.860757	2.860817	2.860877	60
726	2.861236	2.861295	2.861355	2.861415	2.861475	60
727	2.861833	2.861893	2.861952	2.862012	2.862072	60
728	2.862430	2.862489	2.862549	2.862608	2.862668	60
729	2.863025	2.863085	2.863144	2.863204	2.863263	60
730	2.863620	2.863680	2.863739	2.863798	2.863858	59
731	2.864214	2.864274	2.864333	2.864392	2.864452	59
732	2.864808	2.864867	2.864926	2.864985	2.865045	59
733	2.865400	2.865459	2.865518	2.865578	2.865637	59
734	2.865952	2.866051	2.866110	2.866169	2.866228	59
735	2.866583	2.866642	2.866701	2.866760	2.866819	59
736	2.867173	2.867232	2.867291	2.867350	2.867409	59
737	2.867762	2.867821	2.867880	2.867939	2.867997	59
738	2.868350	2.868409	2.868468	2.868527	2.868586	59
739	2.868938	2.868997	2.869056	2.869114	2.869173	59
740	2.869525	2.869584	2.869642	2.869701	2.869760	59
741	2.870111	2.870170	2.870228	2.870287	2.870345	59
742	2.870696	2.870755	2.870813	2.870872	2.870930	58
743	2.871281	2.871339	2.871398	2.871456	2.871515	58
744	2.871865	2.871923	2.871981	2.872040	2.872098	58

Name	0	1	2	3	4	diff.
745	2.872156	2.872215	2.872273	2.872331	2.872389	58
746	2.872739	2.872797	2.872855	2.872913	2.872972	58
747	2.873321	2.873379	2.873437	2.873495	2.873553	58
748	2.873902	2.873960	2.874018	2.874076	2.874134	58
749	2.874482	2.874540	2.874598	2.874656	2.874714	58
750	2.875061	2.875119	2.875177	2.875235	2.875293	58
751	2.875640	2.875698	2.875756	2.875813	2.875871	58
752	2.876218	2.876276	2.876333	2.876391	2.876449	58
753	2.876795	2.876853	2.876910	2.876968	2.877026	58
754	2.877371	2.877429	2.877486	2.877544	2.877602	58
755	2.877947	2.878004	2.878062	2.878119	2.878177	57
756	2.878522	2.878579	2.878637	2.878694	2.878751	57
757	2.879096	2.879153	2.879211	2.879268	2.879325	57
758	2.879669	2.879726	2.879784	2.879841	2.879898	57
759	2.880242	2.880299	2.880356	2.880413	2.880471	57
760	2.880814	2.880871	2.880928	2.880985	2.881042	57
761	2.881385	2.881442	2.881499	2.881556	2.881613	57
762	2.881955	2.882012	2.882069	2.882126	2.882183	57
763	2.882524	2.882581	2.882638	2.882695	2.882752	57
764	2.883093	2.883150	2.883207	2.883264	2.883321	57
765	2.883661	2.883718	2.883775	2.883832	2.883889	57
766	2.884229	2.884285	2.884342	2.884399	2.884455	57
767	2.884795	2.884852	2.884909	2.884965	2.885022	57
768	2.885361	2.885418	2.885474	2.885531	2.885587	57
769	2.885926	2.885983	2.886039	2.886096	2.886152	56
770	2.886491	2.886547	2.886603	2.886660	2.886716	56
771	2.887054	2.887111	2.887167	2.887223	2.887280	56
772	2.887617	2.887673	2.887730	2.887786	2.887842	56
773	2.888179	2.888236	2.888292	2.888348	2.888404	56
774	2.888741	2.888797	2.888853	2.888909	2.888965	56
775	2.889302	2.889358	2.889414	2.889470	2.889526	56
776	2.889862	2.889918	2.889974	2.890030	2.890086	56
777	2.890421	2.890477	2.890533	2.890586	2.890644	56
778	2.890980	2.891035	2.891091	2.891147	2.891203	56
779	2.891537	2.891593	2.891649	2.891705	2.891760	56
780	2.892095	2.892150	2.892206	2.892262	2.892317	56
781	2.892651	2.892707	2.892762	2.892818	2.892873	56
782	2.893207	2.893262	2.893318	2.893373	2.893429	56
783	2.893762	2.893817	2.893873	2.893928	2.893984	55
784	2.894316	2.894371	2.894427	2.894482	2.894538	55
785	2.894870	2.894925	2.894980	2.895036	2.895091	55
786	2.895422	2.895478	2.895533	2.895588	2.895643	55
787	2.895975	2.896030	2.896085	2.896140	2.896195	55

from 1 to 10000

(347)

Num.	5	6	7	8	9	Diff.
745	2.872448	2.872506	2.872564	2.872622	2.872681	58
746	2.873030	2.873088	2.873146	2.873204	2.873262	58
747	2.873611	2.873669	2.873727	2.873785	2.873843	58
748	2.874192	2.874250	2.874308	2.874366	2.874424	58
749	2.874772	2.874830	2.874887	2.874945	2.875003	58
750	2.875351	2.875409	2.875466	2.875524	2.875582	58
751	2.875929	2.875987	2.876045	2.876102	2.876160	58
752	2.876506	2.876564	2.876622	2.876680	2.876737	58
753	2.877083	2.877141	2.877198	2.877256	2.877314	58
754	2.877659	2.877717	2.877774	2.877832	2.877889	58
755	2.878234	2.878292	2.878349	2.878407	2.878464	57
756	2.878809	2.878866	2.878924	2.878981	2.879038	57
757	2.879383	2.879440	2.879497	2.879555	2.879612	57
758	2.879956	2.880013	2.880070	2.880127	2.880185	57
759	2.880528	2.880585	2.880642	2.880699	2.880756	57
760	2.881099	2.881156	2.881213	2.881270	2.881328	57
761	2.881670	2.881727	2.881784	2.881841	2.881898	57
762	2.882240	2.882297	2.882354	2.882411	2.882468	57
763	2.882809	2.882866	2.882923	2.882980	2.883036	57
764	2.883377	2.883434	2.883491	2.883548	2.883605	57
765	2.883945	2.884002	2.884059	2.884116	2.884172	57
766	2.884512	2.884569	2.884625	2.884682	2.884739	57
767	2.885078	2.885135	2.885191	2.885248	2.885305	57
768	2.885644	2.885700	2.885757	2.885813	2.885870	57
769	2.886209	2.886265	2.886321	2.886378	2.886434	56
770	2.886773	2.886829	2.886885	2.886942	2.886998	56
771	2.887336	2.887392	2.887448	2.887505	2.887561	56
772	2.887898	2.887955	2.888011	2.888068	2.888123	56
773	2.888460	2.888516	2.888573	2.888629	2.888685	56
774	2.889021	2.889077	2.889134	2.889190	2.889246	56
775	2.889582	2.889638	2.889694	2.889750	2.889806	56
776	2.890141	2.890197	2.890253	2.890309	2.890365	56
777	2.890700	2.890756	2.890815	2.890868	2.890924	56
778	2.891259	2.891314	2.891370	2.891426	2.891482	56
779	2.891816	2.891872	2.891927	2.891983	2.892039	56
780	2.892373	2.892428	2.892484	2.892540	2.892595	56
781	2.892929	2.892985	2.893040	2.893096	2.893151	56
782	2.893484	2.893540	2.893595	2.893651	2.893706	56
783	2.894039	2.894094	2.894150	2.894205	2.894261	55
784	2.894593	2.894648	2.894704	2.894759	2.894814	55
785	2.895146	2.895201	2.895257	2.895312	2.895367	55
786	2.895699	2.895754	2.895809	2.895864	2.895919	55
787	2.896251	2.896306	2.896361	2.896416	2.896471	55

(348) A Table of Logarithms,

Num.	0	1	2	3	4	Diff.
788	2.896526	2.896581	2.896636	2.896691	2.896747	55
789	2.897077	2.897132	2.897187	2.897242	2.897297	55
790	2.897627	2.897682	2.897737	2.897792	2.897847	55
791	2.898176	2.898231	2.898286	2.898341	2.898396	55
792	2.898725	2.898780	2.898835	2.898890	2.898944	55
793	2.899273	2.899328	2.899383	2.899437	2.899492	55
794	2.899820	2.899875	2.899930	2.899985	2.900039	55
795	2.900367	2.900422	2.900476	2.900531	2.900586	55
796	2.900913	2.900968	2.901022	2.901077	2.901131	55
797	2.901458	2.901513	2.901567	2.901622	2.901676	55
798	2.902003	2.902057	2.902112	2.902166	2.902220	54
799	2.902547	2.902601	2.902655	2.902710	2.902764	54
800	2.903090	2.903144	2.903198	2.903253	2.903307	54
801	2.903632	2.903687	2.903741	2.903795	2.903849	54
802	2.904174	2.904228	2.904283	2.904337	2.904391	54
803	2.904715	2.904770	2.904824	2.904878	2.904931	54
804	2.905256	2.905310	2.905364	2.905418	2.905472	54
805	2.905796	2.905850	2.905904	2.905958	2.906012	54
806	2.906335	2.906389	2.906443	2.906497	2.906550	54
807	2.906873	2.906927	2.906981	2.907035	2.907089	54
808	2.907411	2.907465	2.907519	2.907573	2.907626	54
809	2.907948	2.908002	2.908056	2.908109	2.908163	54
810	2.908485	2.908539	2.908592	2.908646	2.908699	54
811	2.909021	2.909074	2.909128	2.909181	2.909235	53
812	2.909556	2.909609	2.909663	2.909716	2.909770	53
813	2.910090	2.910144	2.910197	2.910251	2.910304	53
814	2.910624	2.910678	2.910731	2.910784	2.910838	53
815	2.911158	2.911211	2.911264	2.911317	2.911371	53
816	2.911690	2.911743	2.911797	2.911850	2.911903	53
817	2.912222	2.912275	2.912328	2.912381	2.912435	53
818	2.912753	2.912806	2.912859	2.912912	2.912966	53
819	2.913284	2.913337	2.913390	2.913443	2.913496	53
820	2.913814	2.913867	2.913920	2.913973	2.914026	53
821	2.914343	2.914396	2.914449	2.914502	2.914555	53
822	2.914872	2.914925	2.914977	2.915030	2.915083	53
823	2.915400	2.915453	2.915505	2.915558	2.915611	53
824	2.915927	2.915980	2.916033	2.916085	2.916138	53
825	2.916454	2.916507	2.916559	2.916602	2.916664	53
826	2.916980	2.917033	2.917085	2.917138	2.917190	53
827	2.917505	2.917558	2.917610	2.917663	2.917715	52
828	2.918030	2.918083	2.918135	2.918188	2.918240	52
829	2.918555	2.918607	2.918659	2.918712	2.918765	52
830	2.919078	2.919130	2.919183	2.919236	2.919287	52

Num	5	6	7	8	9	Diff.
788	2.896802	2.896857	2.896912	2.896967	2.897022	55
789	2.897352	2.897407	2.897462	2.897517	2.897572	55
790	2.897902	2.897957	2.898012	2.898067	2.898122	55
791	2.898451	2.898506	2.898561	2.898615	2.898670	55
792	2.898999	2.899054	2.899109	2.899164	2.899218	55
793	2.899547	2.899602	2.899656	2.899711	2.899766	55
794	2.900094	2.900149	2.900203	2.900258	2.900312	55
795	2.900640	2.900695	2.900749	2.900804	2.900858	55
796	2.901186	2.901240	2.901295	2.901349	2.901404	55
797	2.901731	2.901785	2.901840	2.901894	2.901948	54
798	2.902275	2.902329	2.902384	2.902438	2.902492	54
799	2.902818	2.902873	2.902927	2.902981	2.903036	54
800	2.903361	2.903416	2.903470	2.903524	2.903578	54
801	2.903903	2.903958	2.904012	2.904066	2.904120	54
802	2.904445	2.904499	2.904553	2.904607	2.904661	54
803	2.904986	2.905040	2.905094	2.905148	2.905202	54
804	2.905526	2.905580	2.905634	2.905688	2.905742	54
805	2.906065	2.906119	2.906173	2.906227	2.906281	54
806	2.906604	2.906658	2.906712	2.906766	2.906820	54
807	2.907142	2.907196	2.907250	2.907304	2.907358	54
808	2.907680	2.907734	2.907787	2.907841	2.907895	54
809	2.908217	2.908270	2.908324	2.908378	2.908431	54
810	2.908753	2.908807	2.908860	2.908914	2.908967	54
811	2.909288	2.909342	2.909395	2.909449	2.909502	54
812	2.909823	2.909877	2.909930	2.909984	2.910037	53
813	2.910358	2.910411	2.910464	2.910518	2.910571	53
814	2.910891	2.910944	2.910998	2.911051	2.911104	53
815	2.911424	2.911477	2.911530	2.911584	2.911637	53
816	2.911956	2.912009	2.912063	2.912116	2.912169	53
817	2.912488	2.912541	2.912594	2.912647	2.912700	53
818	2.913019	2.913072	2.913125	2.913178	2.913231	53
819	2.913549	2.913602	2.913655	2.913708	2.913761	53
820	2.914079	2.914131	2.914184	2.914237	2.914290	53
821	2.914608	2.914660	2.914713	2.914766	2.914819	53
822	2.915130	2.915189	2.915241	2.915294	2.915347	53
823	2.915664	2.915716	2.915769	2.915822	2.915874	53
824	2.916191	2.916243	2.916296	2.916349	2.916401	53
825	2.916717	2.916770	2.916822	2.916875	2.916927	53
826	2.917243	2.917295	2.917348	2.917400	2.917453	53
827	2.917768	2.917820	2.917873	2.917925	2.917978	52
828	2.918292	2.918345	2.918397	2.918450	2.918502	52
829	2.918816	2.918869	2.918921	2.918973	2.919026	52
830	2.919340	2.919392	2.919444	2.919496	2.919548	52

Num.	0	1	2	3	4	Diff.
831	2.919601	2.919653	2.919705	2.919757	2.919810	52
832	2.920123	2.920175	2.920228	2.920280	2.920332	52
833	2.920645	2.920697	2.920749	2.920801	2.920853	52
834	2.921166	2.921218	2.921270	2.921322	2.921374	52
835	2.921686	2.921738	2.921790	2.921842	2.921894	52
836	2.922206	2.922258	2.922310	2.922362	2.922414	52
837	2.922725	2.922777	2.922829	2.922881	2.922933	52
838	2.923244	2.923296	2.923348	2.923399	2.923451	52
839	2.923762	2.923814	2.923865	2.923917	2.923969	52
840	2.924279	2.924331	2.924383	2.924434	2.924486	52
841	2.924796	2.924848	2.924899	2.924951	2.925002	52
842	2.925312	2.925364	2.925415	2.925467	2.925518	52
843	2.925828	2.925879	2.925931	2.925982	2.926034	51
844	2.926342	2.926394	2.926445	2.926497	2.926548	51
845	2.926857	2.926908	2.926959	2.927011	2.927062	51
846	2.927370	2.927422	2.927473	2.927524	2.927576	51
847	2.927883	2.927935	2.927986	2.928037	2.928088	51
848	2.928396	2.928447	2.928498	2.928549	2.928601	51
849	2.928908	2.928959	2.929010	2.929061	2.929112	51
850	2.929419	2.929470	2.929521	2.929572	2.929623	51
851	2.929930	2.929981	2.930032	2.930083	2.930134	51
852	2.930440	2.930491	2.930541	2.930592	2.930643	51
853	2.930949	2.931000	2.931051	2.931102	2.931153	51
854	2.931458	2.931509	2.931560	2.931610	2.931661	51
855	2.931966	2.932017	2.932068	2.932118	2.932169	51
856	2.932474	2.932524	2.932575	2.932626	2.932677	51
857	2.932981	2.933031	2.933082	2.933133	2.933183	51
858	2.933487	2.933538	2.933588	2.933639	2.933690	51
859	2.933993	2.934044	2.934094	2.934145	2.934195	51
860	2.934498	2.934549	2.934599	2.934650	2.934700	50
861	2.935003	2.935054	2.935104	2.935154	2.935205	50
862	2.935507	2.935558	2.935608	2.935658	2.935709	50
863	2.936011	2.936061	2.936111	2.936162	2.936212	50
864	2.936514	2.936564	2.936614	2.936664	2.936715	50
865	2.937016	2.937066	2.937116	2.937167	2.937217	50
866	2.937518	2.937568	2.937618	2.937668	2.937718	50
867	2.938019	2.938069	2.938119	2.938169	2.938219	50
868	2.938520	2.938570	2.938620	2.938670	2.938720	50
869	2.939020	2.939070	2.939120	2.939170	2.939220	50
870	2.939519	2.939569	2.939619	2.939669	2.939719	50
871	2.940018	2.940068	2.940118	2.940168	2.940218	50
872	2.940516	2.940566	2.940616	2.940666	2.940716	50
873	2.941014	2.941064	2.941114	2.941163	2.941213	50

from 1 to 10000.

(351)

Num.	5	6	7	8	9	Diff.
831	2.919862	2.919914	2.920067	2.920019	2.920071	52
832	2.920384	2.920436	2.920489	2.920541	2.920593	52
833	2.920906	2.920958	2.921010	2.921062	2.921114	52
834	2.921426	2.921478	2.921530	2.921582	2.921634	52
835	2.921946	2.921998	2.922050	2.922102	2.922154	52
836	2.922466	2.922518	2.922570	2.922622	2.922674	52
837	2.922985	2.923037	2.923088	2.923140	2.923192	52
838	2.923503	2.923555	2.923607	2.923658	2.923710	52
839	2.924021	2.924072	2.924124	2.924176	2.924228	52
840	2.924538	2.924589	2.924641	2.924693	2.924744	52
841	2.925054	2.925106	2.925157	2.925209	2.925260	52
842	2.925570	2.925621	2.925673	2.925724	2.925776	52
843	2.926085	2.926137	2.926188	2.926239	2.926291	52
844	2.926600	2.926651	2.926702	2.926754	2.926805	51
845	2.927114	2.927165	2.927216	2.927268	2.927319	51
846	2.927627	2.927678	2.927730	2.927781	2.927832	51
847	2.928140	2.928191	2.928242	2.928293	2.928345	51
848	2.928652	2.928703	2.928754	2.928805	2.928856	51
849	2.929163	2.929214	2.929266	2.929317	2.929368	51
850	2.929674	2.929725	2.929776	2.929827	2.929878	51
851	2.930185	2.930236	2.930287	2.930338	2.930389	51
852	2.930694	2.930745	2.930796	2.930847	2.930898	51
853	2.931203	2.931254	2.931305	2.931356	2.931407	51
854	2.931712	2.931763	2.931814	2.931864	2.931915	51
855	2.932220	2.932271	2.932321	2.932372	2.932423	51
856	2.932727	2.932778	2.932829	2.932879	2.932930	51
857	2.933234	2.933285	2.933335	2.933386	2.933437	51
858	2.933740	2.933791	2.933841	2.933892	2.933943	51
859	2.934246	2.934296	2.934347	2.934397	2.934448	51
860	2.934751	2.934801	2.934852	2.934902	2.934953	50
861	2.935255	2.935306	2.935356	2.935406	2.935457	50
862	2.935759	2.935809	2.935860	2.935910	2.935960	50
863	2.936262	2.936313	2.936363	2.936413	2.936463	50
864	2.936765	2.936815	2.936865	2.936916	2.936966	50
865	2.937267	2.937317	2.937367	2.937418	2.937468	50
866	2.937769	2.937819	2.937869	2.937919	2.937969	50
867	2.938269	2.938319	2.938370	2.938420	2.938470	50
868	2.938770	2.938820	2.938870	2.938920	2.938970	50
869	2.939270	2.939319	2.939369	2.939419	2.939469	50
870	2.939769	2.939819	2.939868	2.939918	2.939968	50
871	2.940267	2.940317	2.940367	2.940417	2.940467	50
872	2.940765	2.940815	2.940865	2.940915	2.940965	50
873	2.941263	2.941313	2.941362	2.941412	2.941462	50

Num.	0	1	2	3	4	Diff.
874	2.941511	2.941561	2.941611	2.941660	2.941710	50
875	2.942008	2.942058	2.942107	2.942157	2.942206	50
876	2.942504	2.942554	2.942604	2.942653	2.942702	50
877	2.943000	2.943049	2.943099	2.943148	2.943198	49
878	2.943494	2.943544	2.943593	2.943643	2.943692	49
879	2.943989	2.944038	2.944088	2.944137	2.944186	49
880	2.944483	2.944532	2.944581	2.944631	2.944680	49
881	2.944976	2.945025	2.945074	2.945124	2.945173	49
882	2.945469	2.945518	2.945567	2.945616	2.945665	49
883	2.945961	2.946010	2.946059	2.946108	2.946157	49
884	2.946452	2.946501	2.946550	2.946600	2.946649	49
885	2.946943	2.946992	2.947041	2.947090	2.947139	49
886	2.947434	2.947483	2.947532	2.947581	2.947630	49
887	2.947924	2.947973	2.948021	2.948070	2.948119	49
888	2.948413	2.948462	2.948511	2.948560	2.948608	49
889	2.948902	2.948951	2.948999	2.949048	2.949097	49
890	2.949390	2.949439	2.949488	2.949536	2.949585	49
891	2.949878	2.949926	2.949975	2.950024	2.950073	49
892	2.950365	2.950413	2.950462	2.950511	2.950560	49
893	2.950851	2.950900	2.950949	2.950997	2.951046	49
894	2.951337	2.951386	2.951435	2.951483	2.951532	49
895	2.951823	2.951872	2.951920	2.951969	2.952017	49
896	2.952308	2.952356	2.952405	2.952453	2.952502	48
897	2.952792	2.952841	2.952889	2.952938	2.952986	48
898	2.953276	2.953325	2.953373	2.953421	2.953470	48
899	2.953760	2.953808	2.953856	2.953905	2.953953	48
900	2.954242	2.954291	2.954339	2.954387	2.954435	48
901	2.954725	2.954773	2.954821	2.954869	2.954918	48
902	2.955206	2.955255	2.955303	2.955351	2.955399	48
903	2.955688	2.955736	2.955784	2.955832	2.955880	48
904	2.956168	2.956216	2.956264	2.956312	2.956360	48
905	2.956649	2.956697	2.956745	2.956792	2.956840	48
906	2.957128	2.957176	2.957224	2.957272	2.957320	48
907	2.957607	2.957655	2.957703	2.957751	2.957799	48
908	2.958086	2.958134	2.958181	2.958229	2.958277	48
909	2.958564	2.958612	2.958659	2.958707	2.958755	48
910	2.959041	2.959089	2.959137	2.959184	2.959232	48
911	2.959518	2.959560	2.959614	2.959661	2.959709	48
912	2.959995	2.960042	2.960090	2.960138	2.960185	48
913	2.960471	2.960518	2.960566	2.960613	2.960661	48
914	2.960946	2.960994	2.961041	2.961089	2.961136	47
915	2.961421	2.961468	2.961516	2.961563	2.961611	47
916	2.961895	2.961943	2.961990	2.962038	2.962085	47

from 1 to 10000.

(353)

Num.	5	6	7	8	9	Diff
874	2.941760	2.941809	2.941859	2.941909	2.941958	49
875	2.942256	2.942306	2.942355	2.942405	2.942454	49
876	2.942752	2.942801	2.942851	2.942900	2.942950	49
877	2.943247	2.943297	2.943346	2.943396	2.943445	49
878	2.943742	2.943791	2.943841	2.943890	2.943939	49
879	2.944236	2.944285	2.944335	2.944384	2.944433	49
880	2.944729	2.944779	2.944828	2.944877	2.944927	49
881	2.945222	2.945272	2.945321	2.945370	2.945419	49
882	2.945715	2.945764	2.945813	2.945862	2.945911	49
883	2.946207	2.946256	2.946305	2.946354	2.946403	49
884	2.946698	2.946747	2.946796	2.946845	2.946894	49
885	2.947189	2.947238	2.947287	2.947336	2.947385	49
886	2.947679	2.947728	2.947777	2.947826	2.947875	49
887	2.948168	2.948217	2.948266	2.948315	2.948364	49
888	2.948657	2.948706	2.948755	2.948804	2.948853	49
889	2.949146	2.949195	2.949244	2.949292	2.949341	49
890	2.949633	2.949683	2.949731	2.949780	2.949829	49
891	2.950121	2.950170	2.950219	2.950267	2.950316	49
892	2.950608	2.950657	2.950705	2.950754	2.950803	49
893	2.951095	2.951143	2.951192	2.951240	2.951289	49
894	2.951580	2.951629	2.951677	2.951726	2.951774	49
895	2.952066	2.952114	2.952163	2.952211	2.952259	48
896	2.952550	2.952599	2.952647	2.952696	2.952744	48
897	2.953034	2.953083	2.953131	2.953180	2.953228	48
898	2.953518	2.953566	2.953615	2.953663	2.953711	48
899	2.954001	2.954049	2.954098	2.954146	2.954194	48
900	2.954484	2.954532	2.954580	2.954628	2.954677	48
901	2.954966	2.955014	2.955062	2.955110	2.955158	48
902	2.955447	2.955495	2.955543	2.955591	2.955640	48
903	2.955928	2.955976	2.956024	2.956072	2.956120	48
904	2.956409	2.956457	2.956505	2.956553	2.956601	48
905	2.956888	2.956936	2.956984	2.957032	2.957080	48
906	2.957368	2.957416	2.957464	2.957511	2.957559	48
907	2.957847	2.957894	2.957942	2.957990	2.958038	48
908	2.958325	2.958373	2.958420	2.958468	2.958516	48
909	2.958805	2.958850	2.958898	2.958946	2.958994	48
910	2.959280	2.959328	2.959375	2.959423	2.959471	48
911	2.959757	2.959804	2.959852	2.959900	2.959947	48
912	2.960233	2.960281	2.960328	2.960376	2.960423	48
913	2.960709	2.960756	2.960804	2.960851	2.960899	48
914	2.961184	2.961231	2.961279	2.961326	2.961374	48
915	2.961658	2.961706	2.961753	2.961801	2.961848	48
916	2.962132	2.962180	2.962227	2.962275	2.962322	48

Num.	0	1	2	3	4	Diff.
917	2.962369	2.962417	2.962464	2.962511	2.962559	47
918	2.962843	2.962890	2.962937	2.962985	2.963032	47
919	2.963315	2.963363	2.963410	2.963457	2.963504	47
920	2.963788	2.963835	2.963882	2.963929	2.963977	47
921	2.964260	2.964307	2.964354	2.964401	2.964448	47
922	2.964731	2.964778	2.964825	2.964872	2.964919	47
923	2.965202	2.965249	2.965296	2.965343	2.965390	47
924	2.965672	2.965719	2.965766	2.965813	2.965860	47
925	2.966142	2.966189	2.966236	2.966283	2.966329	47
926	2.966611	2.966658	2.966705	2.966752	2.966798	47
927	2.967080	2.967127	2.967173	2.967220	2.967267	47
928	2.967548	2.967595	2.967642	2.967688	2.967735	47
929	2.968016	2.968062	2.968109	2.968156	2.968203	47
930	2.968483	2.968530	2.968576	2.968623	2.968670	47
931	2.968950	2.968996	2.969043	2.969090	2.969136	47
932	2.969416	2.969462	2.969509	2.969556	2.969602	47
933	2.969882	2.969928	2.969975	2.970021	2.970068	47
934	2.970347	2.970393	2.970440	2.970486	2.970533	47
935	2.970812	2.970858	2.970904	2.970951	2.970997	47
936	2.971276	2.971322	2.971369	2.971415	2.971461	47
937	2.971740	2.971786	2.971832	2.971879	2.971925	47
938	2.972203	2.972249	2.972295	2.972342	2.972388	46
939	2.972666	2.972712	2.972758	2.972804	2.972851	46
940	2.973128	2.973174	2.973220	2.973266	2.973313	46
941	2.973590	2.973636	2.973682	2.973728	2.973774	46
942	2.974051	2.974097	2.974143	2.974189	2.974235	46
943	2.974512	2.974558	2.974604	2.974650	2.974696	46
944	2.974972	2.975018	2.975064	2.975110	2.975156	46
945	2.975432	2.975478	2.975524	2.975570	2.975616	46
946	2.975891	2.975937	2.975983	2.976029	2.976075	46
947	2.976350	2.976396	2.976442	2.976487	2.976533	46
948	2.976808	2.976854	2.976900	2.976946	2.976991	46
949	2.977266	2.977312	2.977358	2.977403	2.977449	46
950	2.977724	2.977769	2.977815	2.977861	2.977906	46
951	2.978180	2.978226	2.978272	2.978317	2.978363	46
952	2.978637	2.978683	2.978728	2.978774	2.978819	46
953	2.979093	2.979138	2.979184	2.979230	2.979275	46
954	2.979548	2.979594	2.979639	2.979685	2.979730	46
955	2.980003	2.980049	2.980094	2.980140	2.980185	45
956	2.980458	2.980503	2.980549	2.980594	2.980640	45
957	2.980912	2.980957	2.981003	2.981048	2.981093	45
958	2.981365	2.981411	2.981456	2.981501	2.981547	45
959	2.981819	2.981864	2.981909	2.981954	2.982000	45

from 1 to 10000.

(355)

Num.	5	6	7	8	9	Diff
917	2.962606	2.962653	2.962701	2.962748	2.962795	47
918	2.963079	2.963126	2.963174	2.963221	2.963268	47
919	2.963552	2.963599	2.963646	2.963693	2.963741	47
920	2.964024	2.964071	2.964118	2.964165	2.964212	47
921	2.964495	2.964542	2.964590	2.964637	2.964684	47
922	2.964966	2.965013	2.965060	2.965108	2.965155	47
923	2.965437	2.965484	2.965531	2.965578	2.965625	47
924	2.965907	2.965954	2.966001	2.966048	2.966095	47
925	2.966376	2.966423	2.966470	2.966517	2.966564	47
926	2.966845	2.966892	2.966939	2.966986	2.967033	47
927	2.967314	2.967361	2.967408	2.967454	2.967501	47
928	2.967782	2.967829	2.967875	2.967922	2.967969	47
929	2.968249	2.968296	2.968343	2.968389	2.968436	47
930	2.968716	2.968763	2.968810	2.968856	2.968903	47
931	2.969183	2.969229	2.969276	2.969323	2.969369	47
932	2.969649	2.969695	2.969742	2.969788	2.969835	47
933	2.970114	2.970161	2.970207	2.970254	2.970300	47
934	2.970579	2.970626	2.970672	2.970719	2.970765	47
935	2.971044	2.971090	2.971137	2.971183	2.971229	46
936	2.971508	2.971554	2.971600	2.971647	2.971693	46
937	2.971971	2.972018	2.972064	2.972110	2.972156	46
938	2.972434	2.972480	2.972527	2.972573	2.972619	46
939	2.972897	2.972943	2.972989	2.973035	2.973082	46
940	2.973359	2.973405	2.973451	2.973497	2.973543	46
941	2.973820	2.973866	2.973913	2.973959	2.974005	46
942	2.974281	2.974327	2.974373	2.974420	2.974466	46
943	2.974742	2.974788	2.974834	2.974880	2.974926	46
944	2.975202	2.975248	2.975294	2.975340	2.975386	46
945	2.975661	2.975707	2.975753	2.975799	2.975845	46
946	2.976121	2.976166	2.976212	2.976258	2.976304	46
947	2.976579	2.976625	2.976671	2.976717	2.976762	46
948	2.977037	2.977083	2.977129	2.977175	2.977220	46
949	2.977495	2.977541	2.977586	2.977632	2.977678	46
950	2.977952	2.977998	2.978043	2.978089	2.978135	46
951	2.978407	2.978454	2.978500	2.978546	2.978591	46
952	2.978865	2.978911	2.978956	2.979002	2.979047	46
953	2.979321	2.979366	2.979412	2.979457	2.979503	46
954	2.979776	2.979821	2.979867	2.979912	2.979958	46
955	2.980231	2.980276	2.980322	2.980367	2.980412	45
956	2.980685	2.980730	2.980776	2.980821	2.980867	45
957	2.981139	2.981184	2.981229	2.981275	2.981320	45
958	2.981592	2.981637	2.981683	2.981728	2.981773	45
959	2.982045	2.982090	2.982135	2.982181	2.982226	55

Num.	0	1	2	3	4	Diff.
100	2.982271	2.982316	2.982362	2.982407	2.982452	45
161	2.982723	2.982769	2.982814	2.982859	2.982904	45
162	2.983175	2.983220	2.983265	2.983310	2.983356	45
163	2.983626	2.983671	2.983716	2.983762	2.983807	45
164	2.984077	2.984122	2.984167	2.984212	2.984257	45
165	2.984527	2.984572	2.984617	2.984662	2.984707	45
166	2.985977	2.985022	2.985067	2.985112	2.985157	45
167	2.985426	2.985471	2.985516	2.985561	2.985606	45
168	2.985875	2.985920	2.985965	2.986010	2.986055	45
169	2.986324	2.986369	2.986413	2.986458	2.986503	45
170	2.986772	2.986816	2.986861	2.986906	2.986951	45
171	2.987219	2.987264	2.987309	2.987353	2.987398	45
172	2.987666	2.987711	2.987756	2.987800	2.987845	45
173	2.988113	2.988157	2.988202	2.988247	2.988291	45
174	2.988559	2.988603	2.988648	2.988693	2.988737	45
175	2.989005	2.989049	2.989094	2.989138	2.989183	45
176	2.989450	2.989494	2.989539	2.989583	2.989628	44
177	2.989895	2.989939	2.989983	2.990028	2.990072	44
178	2.990339	2.990383	2.990428	2.990472	2.990516	44
179	2.990783	2.990827	2.990871	2.990916	2.990960	44
180	2.991226	2.991270	2.991315	2.991359	2.991403	44
181	2.991669	2.991713	2.991757	2.991802	2.991846	44
182	2.992111	2.992156	2.992200	2.992244	2.992289	44
183	2.992553	2.992598	2.992642	2.992686	2.992730	44
184	2.992995	2.993039	2.993083	2.993127	2.993172	44
185	2.993436	2.993480	2.993524	2.993568	2.993613	44
186	2.993877	2.993921	2.993965	2.994009	2.994053	44
187	2.994317	2.994361	2.994405	2.994449	2.994493	44
188	2.994757	2.994801	2.994845	2.994889	2.994933	44
189	2.995196	2.995240	2.995284	2.995328	2.995372	44
190	2.995635	2.995679	2.995723	2.995767	2.995811	44
191	2.996074	2.996117	2.996161	2.996205	2.996249	44
192	2.996512	2.996555	2.996599	2.996643	2.996687	44
193	2.996949	2.996993	2.997037	2.997080	2.997124	44
194	2.997386	2.997430	2.997474	2.997517	2.997561	44
195	2.997823	2.997867	2.997910	2.997954	2.997998	44
196	2.998259	2.998303	2.998346	2.998390	2.998434	44
197	2.998695	2.998739	2.998782	2.998826	2.998869	44
198	2.999130	2.999174	2.999218	2.999261	2.999305	44
199	2.999565	2.999609	2.999652	2.999696	2.999739	43

from 1 to 10000.

(357)

Num.	5	0	1	0	9	Diff
900	2.984497	2.982543	2.982588	2.982633	2.982678	45
961	2.982949	2.982994	2.983040	2.983085	2.983130	45
962	2.983401	2.983446	2.983491	2.983536	2.983581	45
963	2.983852	2.983897	2.983942	2.983987	2.984032	45
964	2.984302	2.984347	2.984392	2.984437	2.984482	45
965	2.984752	2.984797	2.984842	2.984887	2.984932	45
966	2.985202	2.985247	2.985292	2.985337	2.985382	45
967	2.985651	2.985696	2.985741	2.985786	2.985830	45
968	2.986100	2.986144	2.986189	2.986234	2.986279	45
969	2.986548	2.986593	2.986637	2.986682	2.986727	45
970	2.986995	2.987040	2.987085	2.987130	2.987174	45
971	2.987443	2.987487	2.987532	2.987577	2.987622	45
972	2.987890	2.987934	2.987979	2.988024	2.988068	45
973	2.988336	2.988381	2.988425	2.988470	2.988514	45
974	2.988782	2.988826	2.988871	2.988915	2.988960	45
975	2.989227	2.989272	2.989316	2.989361	2.989405	45
976	2.989672	2.989717	2.989761	2.989806	2.989850	44
977	2.990117	2.990161	2.990206	2.990250	2.990294	44
978	2.990561	2.990605	2.990650	2.990694	2.990738	44
979	2.991004	2.991049	2.991093	2.991137	2.991182	44
980	2.991448	2.991492	2.991536	2.991580	2.991625	44
981	2.991890	2.991934	2.991979	2.992023	2.992067	44
982	2.992333	2.992377	2.992421	2.992465	2.992509	44
983	2.992774	2.992818	2.992863	2.992907	2.992951	44
984	2.993216	2.993260	2.993304	2.993348	2.993392	44
985	2.993657	2.993701	2.993745	2.993789	2.993833	44
986	2.994097	2.994141	2.994185	2.994229	2.994273	44
987	2.994537	2.994581	2.994625	2.994669	2.994713	44
988	2.994977	2.995021	2.995064	2.995108	2.995152	44
989	2.995416	2.995460	2.995504	2.995547	2.995591	44
990	2.995854	2.995898	2.995942	2.995986	2.996030	44
991	2.996293	2.996336	2.996380	2.996424	2.996468	44
992	2.996730	2.996774	2.996818	2.996862	2.996905	44
993	2.997168	2.997212	2.997255	2.997299	2.997343	44
994	2.997605	2.997648	2.997692	2.997736	2.997779	44
995	2.998041	2.998085	2.998128	2.998172	2.998216	44
996	2.998477	2.998521	2.998564	2.998608	2.998652	44
997	2.998913	2.998956	2.999000	2.999043	2.999087	44
998	2.999348	2.999392	2.999435	2.999478	2.999522	44
999	2.999783	2.999826	2.999870	2.999913	2.999957	43

0 Degrees.

Minutes	Sine		Tang.		Secant		Minutes
	0.000000	10.000000	0.000000	Infinite	10.000000	Infinite	60
1	6.463726	9.999999	6.463726	13.536274	10.000000	13.536274	59
2	6.764756	9.999999	6.764756	13.235244	10.000000	13.235244	58
3	6.940847	9.999999	6.940847	13.059153	10.000000	13.059153	57
4	7.065786	9.999999	7.065786	12.934214	10.000000	12.934214	56
5	7.162696	9.999999	7.162696	12.837304	10.000000	12.837304	55
6	7.241877	9.999999	7.241878	12.758122	10.000001	12.758123	54
7	7.308824	9.999999	7.308825	12.691175	10.000001	12.691176	53
8	7.366816	9.999999	7.366817	12.633183	10.000001	12.633184	52
9	7.417968	9.999999	7.417970	12.582030	10.000001	12.582032	51
10	7.463725	9.999998	7.463727	12.536273	10.000002	12.536275	50
11	7.505118	9.999998	7.505120	12.494880	10.000002	12.494882	49
12	7.542907	9.999997	7.542909	12.457091	10.000003	12.457093	48
13	7.577668	9.999997	7.577671	12.422328	10.000003	12.422332	47
14	7.609853	9.999996	7.609857	12.390143	10.000004	12.390147	46
15	7.639816	9.999996	7.639820	12.360180	10.000004	12.360184	45
16	7.667844	9.999995	7.667849	12.332151	10.000005	12.332156	44
17	7.694173	9.999995	7.694179	12.305821	10.000005	12.305827	43
18	7.718997	9.999994	7.719003	12.280997	10.000006	12.281003	42
19	7.742478	9.999993	7.742484	12.257516	10.000007	12.257522	41
20	7.764754	9.999993	7.764761	12.235239	10.000007	12.235246	40
21	7.785943	9.999992	7.785951	12.214049	10.000008	12.214057	39
22	7.806146	9.999991	7.806155	12.193845	10.000009	12.193854	38
23	7.825451	9.999990	7.825460	12.174540	10.000010	12.174549	37
24	7.843934	9.999989	7.843944	12.156056	10.000011	12.156066	36
25	7.861662	9.999988	7.861674	12.138326	10.000012	12.138338	35
26	7.878695	9.999988	7.878708	12.121292	10.000012	12.121305	34
27	7.895085	9.999987	7.895099	12.104901	10.000013	12.104915	33
28	7.910879	9.999986	7.910894	12.089106	10.000014	12.089121	32
29	7.926119	9.999984	7.926134	12.073866	10.000016	12.073881	31
30	7.940842	9.999983	7.940858	12.059142	10.000017	12.059158	30
	Sine		Tangent		Secant		Minutes

89 Degrees.

Tangents, and Secants.

(359)

0 Degrees.

Minutes	Sine		Táng.		Secant		Minutes
30	7.940842	9.999984	7.940858	12.059142	10.000016	12.059158	30
31	7.955082	9.999982	7.955100	12.044900	10.000018	12.044918	29
32	7.968870	9.999981	7.968889	12.031111	10.000019	12.031130	28
33	7.982233	9.999980	7.982253	12.017747	10.000020	12.017767	27
34	7.995198	9.999979	7.995219	12.004781	10.000021	12.004802	26
35	8.007787	9.999977	8.007809	11.992191	10.000023	11.992213	25
36	8.020221	9.999976	8.020245	11.979955	10.000024	11.979979	24
37	8.031919	9.999975	8.031945	11.968055	10.000025	11.968081	23
38	8.043501	9.999974	8.043527	11.956473	10.000026	11.956499	22
39	8.054781	9.999972	8.054809	11.945191	10.000028	11.945219	21
40	8.065776	9.999971	8.065806	11.934194	10.000029	11.934224	20
41	8.076500	9.999969	8.076531	11.923469	10.000031	11.923500	19
42	8.086965	9.999968	8.086997	11.913003	10.000032	11.913035	18
43	8.097183	9.999966	8.097217	11.902783	10.000034	11.902817	17
44	8.107167	9.999964	8.107202	11.892798	10.000036	11.892833	16
45	8.116926	9.999963	8.116963	11.883037	10.000037	11.883074	15
46	8.126471	9.999961	8.126510	11.873490	10.000039	11.873529	14
47	8.135810	9.999959	8.135851	11.864149	10.000041	11.864190	13
48	8.144953	9.999958	8.144996	11.855004	10.000042	11.855047	12
49	8.153908	9.999956	8.153952	11.846048	10.000044	11.846092	11
50	8.162681	9.999954	8.162727	11.837273	10.000046	11.837319	10
51	8.171280	9.999952	8.171328	11.828672	10.000048	11.828720	9
52	8.179713	9.999950	8.179763	11.820237	10.000050	11.820287	8
53	8.187985	9.999948	8.188036	11.811964	10.000052	11.812015	7
54	8.196102	9.999946	8.196156	11.803844	10.000054	11.803898	6
55	8.204070	9.999944	8.204126	11.795874	10.000056	11.795930	5
56	8.211895	9.999942	8.211953	11.788047	10.000058	11.788105	4
57	8.219581	9.999940	8.219641	11.780359	10.000060	11.780419	3
58	8.227134	9.999938	8.227195	11.772805	10.000062	11.772866	2
59	8.234557	9.999936	8.234621	11.765379	10.000064	11.765443	1
60	8.241855	9.999934	8.241922	11.758078	10.000066	11.758145	0
	Sine		Tangent		Secant		Minutes

89 Degrees.

(360)

A Table of Artificial Sines,

1 Degrees.

Minutes	Sine		Tang.		Secant		Minutes
0	8.241855	9.999934	8.241921	11.758079	10.000066	11.758145	60
1	8.249033	9.999932	8.249101	11.750898	10.000068	11.750967	59
2	8.256094	9.999929	8.256165	11.743835	10.000071	11.743906	58
3	8.263042	9.999927	8.263115	11.736885	10.000073	11.736958	57
4	8.269881	9.999925	8.269956	11.730044	10.000075	11.730119	56
5	8.276614	9.999922	8.276691	11.723309	10.000078	11.723386	55
6	8.283243	9.999920	8.283323	11.716677	10.000080	11.716757	54
7	8.289773	9.999917	8.289856	11.710144	10.000082	11.710227	53
8	8.296207	9.999915	8.296292	11.703708	10.000085	11.703793	52
9	8.302546	9.999912	8.302633	11.697367	10.000087	11.697454	51
10	8.308794	9.999910	8.308884	11.691116	10.000090	11.691206	50
11	8.314954	9.999907	8.315045	11.684954	10.000093	11.685046	49
12	8.321027	9.999905	8.321122	11.678878	10.000095	11.678973	48
13	8.327016	9.999902	8.327114	11.672886	10.000098	11.672984	47
14	8.332924	9.999899	8.333025	11.666975	10.000101	11.667076	46
15	8.338753	9.999897	8.338856	11.661144	10.000103	11.661247	45
16	8.344504	9.999894	8.344610	11.655385	10.000106	11.655496	44
17	8.350180	9.999891	8.350289	11.649710	10.000109	11.649819	43
18	8.355783	9.999888	8.355895	11.644105	10.000112	11.644216	42
19	8.361315	9.999885	8.361430	11.638570	10.000115	11.638685	41
20	8.366777	9.999882	8.366894	11.633105	10.000118	11.633223	40
21	8.372171	9.999879	8.372291	11.627708	10.000121	11.627829	39
22	8.377499	9.999876	8.377622	11.622378	10.000124	11.622501	38
23	8.382762	9.999873	8.382889	11.617111	10.000127	11.617238	37
24	8.387962	9.999870	8.388092	11.611908	10.000130	11.612038	36
25	8.393101	9.999867	8.393234	11.606760	10.000133	11.606899	35
26	8.398179	9.999864	8.398315	11.601685	10.000136	11.601821	34
27	8.403199	9.999861	8.403338	11.596662	10.000139	11.596801	33
28	8.408161	9.999858	8.408304	11.591696	10.000142	11.591839	32
29	8.413068	9.999854	8.413213	11.586787	10.000146	11.586932	31
30	8.417919	9.999851	8.418068	11.581932	10.000149	11.582081	30
	Sine		Tangent		Secant		Minutes

88 Degrees.

Tangents, and Secants.

(361)

1 Degrees.

Minutes	Sine		Tang.		Secant		
30	8.417919	9.999851	8.418068	11.581932	10.000149	11.582081	30
31	8.422717	9.999848	8.422869	11.577131	10.000152	11.577283	29
32	8.427462	9.999844	8.427618	11.572382	10.000156	11.572538	28
33	8.432156	9.999841	8.432315	11.567685	10.000159	11.567844	27
34	8.436800	9.999838	8.436962	11.563038	10.000162	11.563200	26
35	8.441394	9.999834	8.441560	11.558440	10.000166	11.558606	25
36	8.445941	9.999831	8.446110	11.553890	10.000169	11.554059	24
37	8.450440	9.999827	8.450613	11.549387	10.000173	11.549560	23
38	8.454893	9.999823	8.455070	11.544930	10.000177	11.545107	22
39	8.459301	9.999820	8.459481	11.540519	10.000180	11.540699	21
40	8.463665	9.999816	8.463849	11.536151	10.000184	11.536335	20
41	8.467985	9.999812	8.468172	11.531827	10.000188	11.532015	19
42	8.472263	9.999809	8.472454	11.527546	10.000191	11.527737	18
43	8.476498	9.999805	8.476693	11.523307	10.000195	11.523502	17
44	8.480693	9.999801	8.480892	11.519108	10.000199	11.519307	16
45	8.484848	9.999797	8.485050	11.514949	10.000203	11.515152	15
46	8.488963	9.999793	8.489170	11.510830	10.000207	11.511037	14
47	8.493040	9.999790	8.493250	11.506750	10.000210	11.506960	13
48	8.497078	9.999786	8.497293	11.502707	10.000214	11.502922	12
49	8.501080	9.999782	8.501298	11.498702	10.000218	11.498920	11
50	8.505045	9.999778	8.505267	11.494733	10.000222	11.494955	10
51	8.508974	9.999774	8.509200	11.490800	10.000226	11.491026	9
52	8.512867	9.999769	8.513098	11.486902	10.000231	11.487133	8
53	8.516726	9.999765	8.516961	11.483039	10.000235	11.483274	7
54	8.520551	9.999761	8.520790	11.479210	10.000239	11.479449	6
55	8.524343	9.999757	8.524586	11.475414	10.000243	11.475657	5
56	8.528102	9.999753	8.528349	11.471651	10.000247	11.471898	4
57	8.531828	9.999748	8.532080	11.467920	10.000252	11.468172	3
58	8.535523	9.999744	8.535779	11.464221	10.000256	11.464477	2
59	8.539186	9.999740	8.539447	11.460553	10.000260	11.460814	1
60	8.542819	9.999735	8.543084	11.456916	10.000265	11.457181	0
	Sine		Tangent		Secant		Minutes

88 Degrees.

2 Degrees.

Minutes	Sine		Tang.		Secant	
1	542819	9.999735	8.543084	11.456916	10.000265	11.457181
2	546422	9.999731	8.54669	11.453309	10.000269	11.453578
3	54999	9.999727	8.550268	11.449732	10.000273	11.450005
4	553539	9.999722	8.553817	11.446183	10.000278	11.446461
5	557054	9.999717	8.557336	11.442664	10.000283	11.442946
6	56054	9.999713	8.560828	11.439172	10.000287	11.439460
7	563999	9.999708	8.564291	11.435709	10.000292	11.436001
8	567431	9.999704	8.567727	11.432273	10.000296	11.432569
9	570836	9.999699	8.571137	11.428863	10.000301	11.429164
10	574214	9.999694	8.574520	11.425480	10.000306	11.425786
11	577566	9.999689	8.577877	11.422123	10.000311	11.422434
12	580892	9.999685	8.581208	11.418792	10.000315	11.419108
13	584193	9.999680	8.584514	11.415486	10.000320	11.415807
14	587469	9.999675	8.587795	11.412205	10.000325	11.412531
15	590721	9.999670	8.591051	11.408949	10.000337	11.409279
16	593948	9.999665	8.594283	11.405717	10.000335	11.406052
17	597152	9.999660	8.597492	11.402508	10.000340	11.402848
18	600332	9.999655	8.600677	11.399323	10.000345	11.399668
19	603489	9.999650	8.603839	11.396161	10.000350	11.396511
20	606623	9.999645	8.606978	11.393022	10.000355	11.393377
21	609734	9.999640	8.610094	11.389906	10.000360	11.390206
22	612823	9.999635	8.613189	11.386811	10.000365	11.387177
23	615891	9.999629	8.616262	11.383738	10.000371	11.384109
24	618937	9.999624	8.619313	11.380687	10.000376	11.381063
25	621962	9.999619	8.622343	11.377657	10.000381	11.378038
26	624965	9.999614	8.625352	11.374648	10.000386	11.375035
27	627948	9.999608	8.628340	11.371660	10.000392	11.372052
28	630911	9.999603	8.631308	11.368692	10.000397	11.369089
29	633854	9.999597	8.634256	11.365744	10.000403	11.366146
30	636776	9.999592	8.637185	11.362815	10.000408	11.363224
31	639680	9.999587	8.640094	11.359907	10.000413	11.360320
	Sine		Tang.		Secant	Minutes

87 Degrees.

Tangents, and Secants.

(363)

2 Degrees.

Minutes	Sine		Tang.		Secant		
30	8.639680	9.999586	8.640093	11.359907	10.000414	11.360320	30
31	8.642563	9.999581	8.642982	11.357018	10.000419	11.357437	29
32	8.645428	9.999575	8.645853	11.354147	10.000425	11.354572	28
33	8.648274	9.999570	8.648704	11.351296	10.000430	11.351726	27
34	8.651102	9.999564	8.651538	11.348462	10.000436	11.348898	26
35	8.653911	9.999558	8.654352	11.345648	10.000442	11.346089	25
36	8.656702	9.999553	8.657149	11.342851	10.000447	11.343298	24
37	8.659475	9.999547	8.659928	11.340072	10.000453	11.340525	23
38	8.662230	9.999541	8.662689	11.337311	10.000459	11.337770	22
39	8.664968	9.999535	8.665433	11.334567	10.000465	11.335032	21
40	8.667689	9.999529	8.668160	11.331840	10.000471	11.332311	20
41	8.670393	9.999524	8.670870	11.329130	10.000476	11.329607	19
42	8.673080	9.999518	8.673563	11.326437	10.000482	11.326920	18
43	8.675751	9.999512	8.676239	11.323761	10.000488	11.324249	17
44	8.678405	9.999506	8.678900	11.321100	10.000494	11.321595	16
45	8.681043	9.999500	8.681544	11.318456	10.000500	11.318957	15
46	8.683665	9.999494	8.684172	11.315828	10.000506	11.316335	14
47	8.686272	9.999487	8.686784	11.313216	10.000513	11.313728	13
48	8.688863	9.999481	8.689381	11.310618	10.000519	11.311137	12
49	8.691438	9.999475	8.691963	11.308037	10.000525	11.308562	11
50	8.693998	9.999469	8.694529	11.305471	10.000531	11.306022	10
51	8.696543	9.999462	8.697081	11.302919	10.000538	11.303457	9
52	8.699073	9.999456	8.699617	11.300383	10.000544	11.300927	8
53	8.701589	9.999450	8.702139	11.297861	10.000550	11.298411	7
54	8.704090	9.999444	8.704646	11.295354	10.000556	11.295910	6
55	8.706577	9.999437	8.707139	11.292861	10.000563	11.293423	5
56	8.709049	9.999431	8.709619	11.290381	10.000569	11.290951	4
57	8.711508	9.999424	8.712083	11.287917	10.000576	11.288492	3
58	8.713952	9.999418	8.714535	11.285465	10.000582	11.286048	2
59	8.716383	9.999411	8.716972	11.283028	10.000588	11.283617	1
60	8.718800	9.999404	8.719396	11.280604	10.000596	11.281200	0
	Sine		Tangent		Secant		Minutes

87 Degrees.

3 Degrees.

Minutes	Sine		Tang.		Secant	
0	8.718800	9.999404	8.719390	11.280604	10.000596	11.281200
1	8.721204	9.999398	8.721806	11.278194	10.000602	11.278796
2	8.723595	9.999391	8.724203	11.275797	10.000609	11.276405
3	8.725972	9.999384	8.726588	11.273412	10.000616	11.274028
4	8.728337	9.999378	8.728959	11.271041	10.000622	11.271663
5	8.730688	9.999371	8.731317	11.268683	10.000629	11.269312
6	8.733027	9.999364	8.733663	11.266337	10.000636	11.266973
7	8.735353	9.999357	8.735996	11.264004	10.000643	11.264647
8	8.737668	9.999350	8.738317	11.261683	10.000650	11.262332
9	8.739969	9.999343	8.740626	11.259374	10.000657	11.260031
10	8.742259	9.999336	8.742922	11.257078	10.000663	11.257741
11	8.744536	9.999329	8.745207	11.254793	10.000671	11.255464
12	8.746802	9.999322	8.747479	11.252521	10.000678	11.253298
13	8.749055	9.999315	8.749740	11.250260	10.000685	11.250945
14	8.751297	9.999308	8.751989	11.248011	10.000692	11.248703
15	8.753528	9.999301	8.754227	11.245773	10.000699	11.246472
16	8.755747	9.999294	8.756453	11.243547	10.000706	11.244253
17	8.757955	9.999286	8.758668	11.241332	10.000714	11.242045
18	8.760151	9.999279	8.760872	11.239128	10.000721	11.239849
19	8.762337	9.999272	8.763065	11.236935	10.000728	11.237663
20	8.764511	9.999265	8.765246	11.234754	10.000735	11.235489
21	8.766675	9.999257	8.767418	11.232582	10.000743	11.233325
22	8.768827	9.999250	8.769578	11.230422	10.000750	11.231173
23	8.770970	9.999242	8.771727	11.228273	10.000758	11.229030
24	8.773101	9.999235	8.773866	11.226134	10.000765	11.226899
25	8.775223	9.999227	8.775995	11.224005	10.000773	11.224777
26	8.777333	9.999220	8.778114	11.221886	10.000780	11.222667
27	8.779434	9.999212	8.780222	11.219778	10.000788	11.220566
28	8.781524	9.999205	8.782320	11.217680	10.000795	11.218476
29	8.783605	9.999197	8.784408	11.215592	10.000803	11.216395
30	8.785675	9.999189	8.786486	11.213514	10.000811	11.214325
		Sine		Tang.		Secant

86 Degrees.

3 Degrees.

Minutes	Sine		Tang.		Secant		Minutes
30	8.785675	9.999189	8.786486	11.213514	10.000811	11.214325	30
31	8.787736	9.999181	8.788554	11.211446	10.000819	11.212264	29
32	8.789787	9.999174	8.790613	11.209387	10.000826	11.210218	28
33	8.791828	9.999166	8.792662	11.207338	10.000834	11.208172	27
34	8.793859	9.999158	8.794701	11.205299	10.000842	11.206141	26
35	8.795881	9.999150	8.796731	11.203269	10.000850	11.204119	25
36	8.797894	9.999142	8.798752	11.201248	10.000858	11.202106	24
37	8.799897	9.999134	8.800763	11.199237	10.000866	11.200103	23
38	8.801892	9.999126	8.802765	11.197235	10.000874	11.198108	22
39	8.803876	9.999118	8.804758	11.195242	10.000882	11.196124	21
40	8.805852	9.999110	8.806742	11.193258	10.000890	11.194148	20
41	8.807819	9.999102	8.808717	11.191283	10.000898	11.192181	19
42	8.809777	9.999094	8.810683	11.189317	10.000906	11.190223	18
43	8.811726	9.999086	8.812641	11.187359	10.000914	11.188274	17
44	8.813667	9.999077	8.814589	11.185411	10.000923	11.186333	16
45	8.815598	9.999069	8.816529	11.183471	10.000931	11.184402	15
46	8.817522	9.999061	8.818461	11.181539	10.000939	11.182478	14
47	8.819436	9.999052	8.820384	11.179616	10.000948	11.180564	13
48	8.821343	9.999044	8.822298	11.177702	10.000956	11.178657	12
49	8.823240	9.999036	8.824205	11.175795	10.000964	11.176760	11
50	8.825130	9.999027	8.826103	11.173897	10.000973	11.174870	10
51	8.827011	9.999019	8.827992	11.172008	10.000981	11.172989	9
52	8.828884	9.999010	8.829874	11.170126	10.000990	11.171116	8
53	8.830749	9.999002	8.831748	11.168252	10.000998	11.169251	7
54	8.832607	9.998993	8.833613	11.166387	10.001007	11.167393	6
55	8.834456	9.998984	8.835471	11.164529	10.001016	11.165544	5
56	8.836297	9.998976	8.837321	11.162679	10.001024	11.163703	4
57	8.838130	9.998967	8.839163	11.160837	10.001033	11.161870	3
58	8.839956	9.998958	8.841998	11.159002	10.001042	11.160044	2
59	8.841774	9.998950	8.842825	11.157175	10.001050	11.158226	1
60	8.843584	9.998941	8.844644	11.155356	10.001059	11.156416	0
	Sine		Tang.		Secant		Minute

86 Degrees.

Minutes	Sine		Tang.		Secant	
0	8.843584	9.998941	8.844644	11.155356	10.001059	11.156415
1	8.845387	9.998932	8.846455	11.155345	10.001068	11.154613
2	8.847183	9.998923	8.848260	11.1551740	10.001077	11.152817
3	8.848971	9.998914	8.850057	11.149943	10.001086	11.151025
4	8.850751	9.998905	8.851846	11.148154	10.001095	11.149249
5	8.852524	9.998896	8.853628	11.146372	10.001104	11.147476
6	8.854291	9.998887	8.855403	11.144597	10.001113	11.145709
7	8.856049	9.998878	8.857171	11.142829	10.001122	11.143951
8	8.857801	9.998869	8.858932	11.141068	10.001131	11.142199
9	8.859546	9.998860	8.860686	11.139314	10.001140	11.140454
10	8.861283	9.998851	8.862433	11.137567	10.001149	11.138717
11	8.863014	9.998841	8.864173	11.135827	10.001159	11.136986
12	8.864738	9.998832	8.865905	11.134095	10.001168	11.135262
13	8.866455	9.998823	8.867632	11.132368	10.001177	11.133545
14	8.868165	9.998813	8.869351	11.130649	10.001187	11.131835
15	8.869868	9.998804	8.871064	11.128936	10.001196	11.130132
16	8.871565	9.998795	8.872770	11.127230	10.001205	11.128435
17	8.873255	9.998785	8.874469	11.125531	10.001215	11.126745
18	8.874938	9.998776	8.876162	11.123838	10.001224	11.125062
19	8.876615	9.998766	8.877849	11.122151	10.001234	11.123385
20	8.878285	9.998757	8.879529	11.120471	10.001243	11.121715
21	8.879949	9.998747	8.881202	11.118798	10.001253	11.120051
22	8.881607	9.998737	8.882869	11.117131	10.001261	11.118393
23	8.883258	9.998728	8.884530	11.115470	10.001272	11.116742
24	8.884903	9.998718	8.886185	11.113815	10.001282	11.115097
25	8.886542	9.998708	8.887833	11.112167	10.001292	11.113458
26	8.888174	9.998699	8.889476	11.110524	10.001301	11.111826
27	8.889801	9.998689	8.891112	11.108888	10.001311	11.110199
28	8.891421	9.998679	8.892742	11.107258	10.001321	11.108579
29	8.893035	9.998669	8.894366	11.105634	10.001331	11.106965
30	8.894643	9.998659	8.895981	11.104016	10.001341	11.105355
	Sine		Tang.		Secant	Minutes

4 Degrees.

Minutes	Sine		Tang.		Secant		Minutes
30	8.894643	9.998659	8.895984	11.104016	10.001341	11.105357	30
31	8.896245	9.998649	8.897596	11.102404	10.001351	11.103754	29
32	8.897842	9.998639	8.899203	11.100797	10.001361	11.102158	28
33	8.899432	9.998629	8.900803	11.099197	10.001371	11.100568	27
34	8.901017	9.998619	8.902398	11.097602	10.001381	11.098983	26
35	8.902590	9.998609	8.903987	11.096013	10.001391	11.097404	25
36	8.904169	9.998599	8.905570	11.094430	10.001401	11.095831	24
37	8.905736	9.998589	8.907147	11.092853	10.001411	11.094264	23
38	8.907297	9.998578	8.908719	11.091281	10.001422	11.092703	22
39	8.908854	9.998568	8.910285	11.089715	10.001432	11.091146	21
40	8.910404	9.998558	8.911846	11.088154	10.001442	11.089596	20
41	8.911949	9.998548	8.913401	11.086599	10.001452	11.088051	19
42	8.913488	9.998537	8.914951	11.085049	10.001463	11.086512	18
43	8.915022	9.998527	8.916495	11.083505	10.001473	11.084978	17
44	8.916550	9.998516	8.918034	11.081966	10.001484	11.083450	16
45	8.918073	9.998506	8.919567	11.080432	10.001494	11.081927	15
46	8.919591	9.998495	8.921096	11.078904	10.001505	11.080409	14
47	8.921103	9.998485	8.922619	11.077381	10.001515	11.078897	13
48	8.922611	9.998474	8.924136	11.075864	10.001526	11.077389	12
49	8.924112	9.998464	8.925649	11.074351	10.001536	11.075888	11
50	8.925609	9.998453	8.927150	11.072844	10.001547	11.074391	10
51	8.927100	9.998442	8.928658	11.071342	10.001558	11.072900	9
52	8.928587	9.998431	8.930155	11.069845	10.001569	11.071413	8
53	8.930068	9.998421	8.931647	11.068353	10.001579	11.069932	7
54	8.931544	9.998410	8.933134	11.066866	10.001590	11.068456	6
55	8.933015	9.998399	8.934616	11.065384	10.001601	11.066985	5
56	8.934481	9.998388	8.936093	11.063907	10.001612	11.065519	4
57	8.935942	9.998377	8.937565	11.062435	10.001622	11.064056	3
58	8.937398	9.998366	8.939032	11.060968	10.001633	11.062602	2
59	8.938850	9.998355	8.940494	11.059506	10.001644	11.061150	1
60	8.940296	9.998344	8.941951	11.058048	10.001655	11.059704	0
	Sine		Tang.		Secant		Minutes

85 Degrees.

5 Degrees.

Minutes	Sine		Tang.		Secant		Minutes
0	8.940290	7.998344	8.941952	11.058048	10.001056	11.059704	60
1	8.941738	7.998333	8.943404	11.056596	10.001667	11.058262	59
2	8.943174	7.998322	8.944852	11.055148	10.001678	11.056826	58
3	8.944606	7.998311	8.946295	11.053705	10.001689	11.055394	57
4	8.946034	7.998300	8.947734	11.052266	10.001700	11.053966	56
5	8.947456	7.998289	8.949168	11.050832	10.001711	11.052544	55
6	8.948874	7.998277	8.950597	11.049403	10.001723	11.051126	54
7	8.950287	7.998266	8.952021	11.047979	10.001734	11.049713	53
8	8.951696	7.998255	8.953441	11.046559	10.001745	11.048304	52
9	8.953100	7.998243	8.954856	11.045144	10.001757	11.046900	51
10	8.954499	7.998232	8.956267	11.043733	10.001768	11.045501	50
11	8.955894	7.998220	8.957673	11.042327	10.001780	11.044106	49
12	8.957284	7.998209	8.959075	11.040925	10.001791	11.042716	48
13	8.958670	7.998197	8.960473	11.039527	10.001803	11.041330	47
14	8.960052	7.998186	8.961866	11.038134	10.001814	11.039948	46
15	8.961429	7.998174	8.963254	11.036746	10.001826	11.038571	45
16	8.962801	7.998163	8.964639	11.035361	10.001837	11.037199	44
17	8.964170	7.998151	8.966019	11.033981	10.001849	11.035830	43
18	8.965534	7.998139	8.967394	11.032606	10.001861	11.034466	42
19	8.966893	7.998127	8.968766	11.031234	10.001873	11.033107	41
20	8.968249	7.998116	8.970133	11.029867	10.001884	11.031751	40
21	8.969600	7.998104	8.971496	11.028504	10.001896	11.030400	39
22	8.970947	7.998092	8.972855	11.027145	10.001908	11.029053	38
23	8.972289	7.998080	8.974209	11.025791	10.001920	11.027711	37
24	8.973628	7.998068	8.975560	11.024440	10.001932	11.026372	36
25	8.974962	7.998056	8.976906	11.023094	10.001944	11.025038	35
26	8.976293	7.998044	8.978248	11.021752	10.001956	11.023707	34
27	8.977619	7.998032	8.979586	11.020414	10.001968	11.022381	33
28	8.978941	7.998020	8.980921	11.019079	10.001980	11.021059	32
29	8.980259	7.998008	8.982251	11.017749	10.001992	11.019741	31
30	8.981573	7.997996	8.983577	11.016423	10.002004	11.018427	30
	Sine		Tang.		Secant		Minutes

84 Degrees.

Tangents, and Secants.

(369)

5 Degrees.

Minutes	Sine		Tang.		Secant		Minutes
30	8.981573	9.997996	8.983577	11.016423	10.002004	11.018427	30
31	8.982883	9.997984	8.984899	11.015101	10.002016	11.017117	29
32	8.984189	9.997972	8.986217	11.013783	10.002028	11.015811	28
33	8.985491	9.997959	8.987532	11.012468	10.002041	11.014509	27
34	8.986789	9.997947	8.988842	11.011158	10.002053	11.013211	26
35	8.988083	9.997935	8.990149	11.009851	10.002065	11.011917	25
36	8.989374	9.997922	8.991451	11.008549	10.002078	11.010626	24
37	8.990660	9.997910	8.992750	11.007250	10.002090	11.009340	23
38	8.991943	9.997897	8.994045	11.005955	10.002103	11.008057	22
39	8.993222	9.997885	8.995337	11.004663	10.002115	11.006778	21
40	8.994497	9.997873	8.996624	11.003376	10.002127	11.005503	20
41	8.995768	9.997859	8.997908	11.002092	10.002141	11.004232	19
42	8.997036	9.997847	8.999188	11.000812	10.002153	11.002964	18
43	8.998299	9.997835	9.000465	10.999535	10.002165	11.001701	17
44	8.999559	9.997822	9.001738	10.998262	10.002178	11.000441	16
45	9.000816	9.997809	9.003007	10.996993	10.002191	10.999184	15
46	9.002069	9.997797	9.004272	10.995728	10.002203	10.997931	14
47	9.003318	9.997784	9.005534	10.994466	10.002216	10.996682	13
48	9.004563	9.997771	9.006792	10.993208	10.002229	10.995437	12
49	9.005805	9.997758	9.008047	10.991953	10.002242	10.994195	11
50	9.007044	9.997745	9.009298	10.990702	10.002255	10.992956	10
51	9.008278	9.997732	9.010546	10.989454	10.002268	10.991722	9
52	9.009510	9.997719	9.011790	10.988210	10.002281	10.990490	8
53	9.010737	9.997706	9.013031	10.986969	10.002294	10.989263	7
54	9.011962	9.997693	9.014268	10.985732	10.002307	10.988038	6
55	9.013182	9.997680	9.015502	10.984498	10.002320	10.986818	5
56	9.014400	9.997667	9.016733	10.983267	10.002333	10.985600	4
57	9.015613	9.997654	9.017959	10.982041	10.002346	10.984387	3
58	9.016824	9.997641	9.019183	10.980817	10.002359	10.983176	2
59	9.018031	9.997628	9.020403	10.979597	10.002372	10.981969	1
60	9.019235	9.997614	9.021620	10.978380	10.002386	10.980765	0
	Sine		Tang.		Secant		Minutes

84 Degrees.

A a

Minutes	Sine		Tang.		Secant		
0	9.019235	9.997614	9.021620	10.978380	10.002386	10.980765	63
1	9.020435	9.997601	9.022834	10.977166	10.002399	10.979565	59
2	9.021632	9.997588	9.024044	10.975956	10.002412	10.978368	58
3	9.022825	9.997574	9.025251	10.974749	10.002426	10.977175	57
4	9.024016	9.997561	9.026455	10.973545	10.002439	10.975984	56
5	9.025203	9.997547	9.027655	10.972345	10.002453	10.974797	55
6	9.026386	9.967534	9.028852	10.971148	10.002466	10.973614	54
7	9.027567	9.997521	9.030046	10.969954	10.002479	10.972433	53
8	9.028744	9.997507	9.031237	10.968763	10.002493	10.971256	52
9	9.029918	9.997493	9.032425	10.967575	10.002507	10.970082	51
10	9.031089	9.997480	9.033609	10.966391	10.002520	10.968911	50
11	9.032257	9.997466	9.034791	10.965209	10.002534	10.967743	49
12	9.033421	9.997452	9.035969	10.964031	10.002548	10.966579	48
13	9.034582	9.997439	9.037144	10.962856	10.002561	10.965418	47
14	9.035741	9.997425	9.038316	10.961684	10.002575	10.964259	46
15	9.036896	9.997411	9.039485	10.960515	10.002588	10.963104	45
16	9.038048	9.997397	9.040651	10.959349	10.002603	10.961952	44
17	9.039197	9.997383	9.041813	10.958187	10.002617	10.960803	43
18	9.040342	9.997369	9.042973	10.957027	10.002631	10.959658	42
19	9.041485	9.997355	9.044130	10.955870	10.002645	10.958515	41
20	9.042625	9.997341	9.045284	10.954716	10.002659	10.957375	40
21	9.043762	9.997327	9.046434	10.953566	10.002673	10.956238	39
22	9.044895	9.997313	9.047582	10.952418	10.002687	10.955105	38
23	9.046026	9.997299	9.048727	10.951273	10.002701	10.953974	37
24	9.047154	9.997285	9.049869	10.950131	10.002715	10.952846	36
25	9.048279	9.997271	9.051008	10.948992	10.002729	10.951721	35
26	9.049400	9.997257	9.052144	10.947856	10.002743	10.950600	34
27	9.050511	9.997242	9.053277	10.946723	10.002757	10.949481	33
28	9.051635	9.997228	9.054407	10.945593	10.002772	10.948365	32
29	9.052745	9.997214	9.055535	10.944465	10.002786	10.947252	31
30	9.053855	9.997199	9.056651	10.943341	10.002801	10.946141	30
		Sine		Tang.		Secant	Minutes

Tangents, and Secants.

(371)

6 Degrees.

Minutes	Sine		Tang.		Secant		Minutes
30	9.053859	9.997199	9.056659	10.943341	10.002801	10.946141	30
31	9.054966	9.997185	9.057781	10.942219	10.002815	10.945034	29
32	9.056071	9.997170	9.058900	10.941100	10.002830	10.943929	28
33	9.057172	9.997156	9.060016	10.939984	10.002844	10.942828	27
34	9.058271	9.997141	9.061130	10.938870	10.002859	10.941729	26
35	9.059367	9.997127	9.062240	10.937760	10.002873	10.940633	25
36	9.060460	9.997112	9.063348	10.936652	10.002888	10.939540	24
37	9.061551	9.997098	9.064453	10.935547	10.002902	10.938449	23
38	9.062639	9.997083	9.065556	10.934444	10.002917	10.937361	22
39	9.063723	9.997068	9.066655	10.933345	10.002932	10.936277	21
40	9.064806	9.997053	9.067752	10.932248	10.002947	10.935194	20
41	9.065885	9.997039	9.068846	10.931154	10.002961	10.934115	19
42	9.066962	9.997024	9.069938	10.930062	10.002976	10.933038	18
43	9.068036	9.997009	9.071027	10.928973	10.002991	10.931964	17
44	9.069107	9.996994	9.072113	10.927887	10.003006	10.930893	16
45	9.070176	9.996979	9.073197	10.926803	10.003021	10.929824	15
46	9.071242	9.996964	9.074278	10.925722	10.003036	10.928758	14
47	9.072305	9.996949	9.075356	10.924644	10.003051	10.927695	13
48	9.073366	9.996934	9.076432	10.923568	10.003066	10.926634	12
49	9.074424	9.996919	9.077505	10.922495	10.003081	10.925576	11
50	9.075480	9.996904	9.078576	10.921424	10.003096	10.924520	10
51	9.076533	9.996889	9.079644	10.920356	10.003111	10.923467	9
52	9.077583	9.996874	9.080710	10.919290	10.003126	10.922417	8
53	9.078631	9.996858	9.081773	10.918227	10.003142	10.921369	7
54	9.079676	9.996843	9.082833	10.917167	10.003157	10.920324	6
55	9.080719	9.996828	9.083891	10.916109	10.003172	10.919281	5
56	9.081759	9.996812	9.084947	10.915055	10.003188	10.918241	4
57	9.082797	9.996797	9.086000	10.914000	10.003203	10.917203	3
58	9.083832	9.996782	9.087050	10.912950	10.003218	10.916168	2
59	9.084864	9.996766	9.088098	10.911902	10.003234	10.915130	1
60	9.085894	9.996751	9.089144	10.910856	10.003249	10.914106	0
	Sine		Tang.		Secant		

83 Degrees.

7. Degrees.

Minutes	Sine		Tang.		Secant	
1	9.055043	9.996751	9.089144	10.910856	10.003249	10.914105
2	9.086922	9.996735	9.090187	10.909813	10.003265	10.913078
3	9.08794	9.996720	9.091228	10.908772	10.003280	10.912053
4	9.088970	9.996704	9.092266	10.907734	10.003296	10.911030
5	9.089990	9.996688	9.093302	10.906698	10.003312	10.910010
6	9.091000	9.996673	9.094335	10.905665	10.003327	10.908992
7	9.09204	9.996657	9.095367	10.904633	10.003343	10.907976
8	9.093037	9.996641	9.096395	10.903605	10.003359	10.906963
9	9.094047	9.996625	9.097422	10.902578	10.003375	10.905953
10	9.095056	9.996610	9.098446	10.901554	10.003390	10.904944
11	9.096062	9.996594	9.099408	10.900532	10.003406	10.903938
12	9.097065	9.996578	9.100487	10.899513	10.003422	10.902935
13	9.098066	9.996562	9.101504	10.898496	10.003438	10.901934
14	9.099065	9.996546	9.102519	10.897481	10.003454	10.900935
15	9.100062	9.996530	9.103532	10.896468	10.003470	10.899938
16	9.101056	9.996514	9.104542	10.895458	10.003486	10.898944
17	9.102048	9.996498	9.105550	10.894450	10.003502	10.897952
18	9.103037	9.996482	9.106556	10.893444	10.003518	10.896963
19	9.104025	9.996465	9.107559	10.892441	10.003535	10.895975
20	9.105010	9.996449	9.108560	10.891440	10.003551	10.894990
21	9.105992	9.996433	9.109559	10.890441	10.003567	10.894008
22	9.106973	9.996417	9.110556	10.889444	10.003583	10.893027
23	9.107951	9.996400	9.111552	10.888449	10.003600	10.892049
24	9.108927	9.996384	9.112543	10.887457	10.003616	10.891073
25	9.109901	9.996368	9.113533	10.886467	10.003632	10.890099
26	9.110873	9.996351	9.114521	10.885479	10.003649	10.889127
27	9.111842	9.996335	9.115507	10.884493	10.003665	10.888158
28	9.112809	9.996318	9.116491	10.883509	10.003682	10.887191
29	9.113774	9.996302	9.117472	10.882528	10.003698	10.886226
30	9.114737	9.996285	9.118452	10.881548	10.003715	10.885263
31	9.115698	9.996269	9.119427	10.880571	10.003731	10.884302
		Sine		Tang.		Secant

82 Degrees.

Tangents, and Secants.

(373)

7 Degrees.

Minutes	Sine		Tang.		Secant		Minutes
30	9.115698	9.996269	9.119429	10.880571	10.003731	10.880430	30
31	9.116656	9.996252	9.120404	10.879596	10.003748	10.883344	29
32	9.117612	9.996235	9.121377	10.878623	10.003765	10.882388	28
33	9.118567	9.996218	9.122348	10.877652	10.003782	10.881433	27
34	9.119519	9.996202	9.123317	10.876683	10.003798	10.880481	26
35	9.120469	9.996185	9.124284	10.875716	10.003815	10.879531	25
36	9.121417	9.996168	9.125249	10.874751	10.003832	10.878583	24
37	9.122362	9.996151	9.126211	10.873789	10.003849	10.877638	23
38	9.123306	9.996134	9.127172	10.872828	10.003866	10.876694	22
39	9.124248	9.996117	9.128130	10.871870	10.003883	10.875752	21
40	9.125187	9.996100	9.129087	10.870913	10.003900	10.874813	20
41	9.126125	9.996083	9.130041	10.869959	10.003917	10.873875	19
42	9.127060	9.996066	9.130994	10.869006	10.003934	10.872940	18
43	9.127993	9.996049	9.131944	10.868056	10.003951	10.872007	17
44	9.128925	9.996032	9.132893	10.867107	10.003968	10.871075	16
45	9.129854	9.996015	9.133839	10.866161	10.003985	10.870140	15
46	9.130781	9.995998	9.134783	10.865217	10.004002	10.869219	14
47	9.131706	9.995980	9.135726	10.864274	10.004020	10.868294	13
48	9.132630	9.995963	9.136666	10.863334	10.004037	10.867370	12
49	9.133551	9.995946	9.137605	10.862395	10.004054	10.866449	11
50	9.134470	9.995928	9.138542	10.861458	10.004072	10.865530	10
51	9.135387	9.995911	9.139476	10.860524	10.004089	10.864613	9
52	9.136303	9.995894	9.140409	10.859591	10.004106	10.863697	8
53	9.137216	9.995876	9.141340	10.858660	10.004124	10.862784	7
54	9.138127	9.995859	9.142269	10.857731	10.004141	10.861873	6
55	9.139037	9.995841	9.143196	10.856804	10.004159	10.860963	5
56	9.139944	9.995823	9.144121	10.855879	10.004177	10.860056	4
57	9.140850	9.995806	9.145044	10.854956	10.004194	10.859150	3
58	9.141754	9.995788	9.145965	10.854035	10.004212	10.858245	2
59	9.142655	9.995770	9.146885	10.853115	10.004230	10.857345	1
60	9.143555	9.995753	9.147802	10.852198	10.004247	10.856445	0
	Sine		Tangent		Secant		Minutes

83 Degrees.

A a 3

8 Degrees.

Minutes	Sine		Tang.		Secant		Minutes
0	9.143555	9.995753	9.147802	10.852198	10.004247	10.856445	60
1	9.144453	9.995735	9.148718	10.851282	10.004265	10.855547	59
2	9.145349	9.995717	9.149632	10.850368	10.004283	10.854651	58
3	9.146243	9.995699	9.150544	10.849456	10.004301	10.853757	57
4	9.147136	9.995681	9.151454	10.848546	10.004319	10.852864	56
5	9.148026	9.995663	9.152363	10.847637	10.004337	10.851974	55
6	9.148915	9.995646	9.153269	10.846731	10.004354	10.851085	54
7	9.149801	9.995628	9.154174	10.845826	10.004372	10.850199	53
8	9.150686	9.995609	9.155077	10.844923	10.004391	10.849314	52
9	9.151569	9.995591	9.155978	10.844022	10.004409	10.848431	51
10	9.152451	9.995573	9.156877	10.843123	10.004427	10.847549	50
11	9.153330	9.995555	9.157775	10.842225	10.004445	10.846670	49
12	9.154208	9.995537	9.158671	10.841329	10.004463	10.845792	48
13	9.155083	9.995519	9.159565	10.840435	10.004481	10.844917	47
14	9.155957	9.995500	9.160457	10.839543	10.004500	10.844043	46
15	9.156830	9.995482	9.161347	10.838653	10.004518	10.843170	45
16	9.157700	9.995464	9.162236	10.837764	10.004536	10.842300	44
17	9.158569	9.995445	9.163123	10.836877	10.004555	10.841431	43
18	9.159435	9.995427	9.164008	10.835992	10.004573	10.840565	42
19	9.160300	9.995409	9.164892	10.835108	10.004591	10.839700	41
20	9.161164	9.995390	9.165774	10.834226	10.004610	10.838836	40
21	9.162025	9.995372	9.166654	10.833346	10.004628	10.837975	39
22	9.162885	9.995353	9.167532	10.832468	10.004647	10.837115	38
23	9.163743	9.995334	9.168409	10.831591	10.004666	10.836257	37
24	9.164600	9.995316	9.169284	10.830716	10.004684	10.835400	36
25	9.165454	9.995297	9.170157	10.829843	10.004703	10.834546	35
26	9.166307	9.995278	9.171029	10.828971	10.004722	10.833695	34
27	9.167159	9.995260	9.171899	10.828101	10.004740	10.832841	33
28	9.168008	9.995241	9.172767	10.827233	10.004759	10.831992	32
29	9.168856	9.995222	9.173634	10.826366	10.004778	10.831144	31
30	9.169702	9.995203	9.174499	10.825501	10.004797	10.830298	30
	Sine		Tangent		Secant		Minutes

8. Degrees.

8 Degrees.

Minutes	Sine		Tang.		Secant		Minutes
30	9.169702	9.995203	9.174499	10.825501	10.004797	10.820298	30
31	9.170546	9.995184	9.175362	10.824638	10.004816	10.829454	29
32	9.171389	9.995165	9.176224	10.823776	10.004835	10.828611	28
33	9.172230	9.995146	9.177084	10.822916	10.004854	10.827770	27
34	9.173070	9.995127	9.177942	10.822058	10.004873	10.826930	26
35	9.173908	9.995108	9.178799	10.821201	10.004892	10.826092	25
36	9.174744	9.995089	9.179655	10.820345	10.004911	10.825256	24
37	9.175578	9.995070	9.180508	10.819492	10.004930	10.824422	23
38	9.176411	9.995051	9.181360	10.818640	10.004949	10.823589	22
39	9.177242	9.995032	9.182211	10.817789	10.004968	10.822758	21
40	9.178072	9.995013	9.183059	10.816941	10.004987	10.821928	20
41	9.178900	9.994993	9.183907	10.816093	10.005007	10.821100	19
42	9.179726	9.994974	9.184752	10.815248	10.005026	10.820274	18
43	9.180551	9.994955	9.185597	10.814403	10.005045	10.819449	17
44	9.181374	9.994935	9.186439	10.813561	10.005065	10.818626	16
45	9.182196	9.994916	9.187280	10.812720	10.005084	10.817804	15
46	9.183016	9.994896	9.188120	10.811880	10.005104	10.816984	14
47	9.183834	9.994877	9.188957	10.811043	10.005123	10.816166	13
48	9.184651	9.994857	9.189794	10.810206	10.005143	10.815349	12
49	9.185466	9.994838	9.190629	10.809371	10.005162	10.814534	11
50	9.186280	9.994818	9.191462	10.808538	10.005182	10.813720	10
51	9.187097	9.994798	9.192294	10.807706	10.005202	10.812908	9
52	9.187905	9.994779	9.193124	10.806876	10.005221	10.812097	8
53	9.188712	9.994759	9.193953	10.806047	10.005241	10.811288	7
54	9.189519	9.994739	9.194780	10.805220	10.005261	10.810481	6
55	9.190325	9.994719	9.195606	10.804394	10.005281	10.809675	5
56	9.191130	9.994700	9.196430	10.803570	10.005300	10.808870	4
57	9.191933	9.994680	9.197253	10.802747	10.005320	10.808067	3
58	9.192734	9.994660	9.198074	10.801926	10.005340	10.807266	2
59	9.193534	9.994640	9.198894	10.801106	10.005360	10.806466	1
60	9.194332	9.994620	9.199712	10.800288	10.005380	10.805668	0
	Sine		Tangent		Secant		Minutes

81 Degrees.

9 Degrees.

Minutes	Sine		Tang.		Secant	
0	9.194332	9.994620	9.199712	10.800288	10.005380	10.805668
1	9.195129	9.994600	9.200529	10.799471	10.005400	10.804871
2	9.195925	9.994580	9.201345	10.798655	10.005420	10.804075
3	9.196719	9.994560	9.202159	10.797841	10.005440	10.803281
4	9.197511	9.994540	9.202971	10.797029	10.005460	10.802489
5	9.198302	9.994519	9.203782	10.796218	10.005481	10.801698
6	9.199091	9.994499	9.204592	10.795408	10.005501	10.800909
7	9.199879	9.994479	9.205400	10.794600	10.005521	10.800121
8	9.200666	9.994459	9.206207	10.793793	10.005541	10.799334
9	9.201451	9.994438	9.207013	10.792987	10.005562	10.798549
10	9.202234	9.994418	9.207817	10.792183	10.005582	10.797766
11	9.203017	9.994397	9.208619	10.791381	10.005603	10.796983
12	9.203797	9.994377	9.209420	10.790580	10.005623	10.796203
13	9.204577	9.994357	9.210220	10.789780	10.005643	10.795423
14	9.205354	9.994336	9.211018	10.788982	10.005664	10.794646
15	9.206131	9.994316	9.211815	10.788185	10.005684	10.793869
16	9.206906	9.994295	9.212611	10.787389	10.005705	10.793094
17	9.207679	9.994274	9.213405	10.786595	10.005726	10.792321
18	9.208452	9.994254	9.214198	10.785802	10.005746	10.791548
19	9.209222	9.994233	9.214989	10.785011	10.005767	10.790778
20	9.209992	9.994212	9.215779	10.784221	10.005788	10.790008
21	9.210760	9.994191	9.216568	10.783432	10.005809	10.789240
22	9.211526	9.994171	9.217356	10.782644	10.005829	10.788474
23	9.212291	9.994150	9.218142	10.781858	10.005850	10.787709
24	9.213055	9.994129	9.218926	10.781074	10.005871	10.786945
25	9.213818	9.994108	9.219710	10.780290	10.005892	10.786182
26	9.214579	9.994087	9.220492	10.779508	10.005913	10.785421
27	9.215338	9.994066	9.221272	10.778728	10.005934	10.784662
28	9.216097	9.994045	9.222052	10.777948	10.005955	10.783903
29	9.216854	9.994024	9.222830	10.777170	10.005976	10.783146
30	9.217609	9.994003	9.223606	10.776394	10.005997	10.782391
	Sine		Tangent		Secant	Minutes

80 Degrees.

Tangents, and Secants.

(377)

9. Degrees.

Minutes	Sine		Tang.		Secant		Minutes
30	9.217609	9.994003	9.223006	10.776394	10.005997	10.782391	30
31	9.218363	9.993981	9.224382	10.775618	10.006019	10.781637	29
32	9.219116	9.993960	9.225156	10.774844	10.006040	10.780884	28
33	9.219868	9.993939	9.225929	10.774071	10.006061	10.780132	27
34	9.220618	9.993918	9.226700	10.773300	10.006082	10.779382	26
35	9.221367	9.993896	9.227471	10.772529	10.006104	10.778633	25
36	9.222115	9.993875	9.228239	10.771761	10.006125	10.777885	24
37	9.222861	9.993854	9.229007	10.770993	10.006146	10.777139	23
38	9.223606	9.993832	9.229774	10.770226	10.006168	10.776394	22
39	9.224349	9.993811	9.230539	10.769461	10.006189	10.775651	21
40	9.225092	9.993789	9.231302	10.768698	10.006211	10.774908	20
41	9.225833	9.993768	9.232065	10.767935	10.006232	10.774167	19
42	9.226573	9.993746	9.232826	10.767174	10.006254	10.773427	18
43	9.227311	9.993725	9.233586	10.766414	10.006275	10.772689	17
44	9.228048	9.993703	9.234345	10.765655	10.006297	10.771952	16
45	9.228784	9.993681	9.235103	10.764897	10.006319	10.771216	15
46	9.229519	9.993660	9.235859	10.764141	10.006340	10.770481	14
47	9.230252	9.993638	9.236614	10.763386	10.006362	10.769748	13
48	9.230984	9.993616	9.237368	10.762632	10.006384	10.769016	12
49	9.231715	9.993594	9.238120	10.761880	10.006406	10.768285	11
50	9.232444	9.993572	9.238872	10.761128	10.006428	10.767556	10
51	9.233172	9.993550	9.239622	10.760378	10.006450	10.766828	9
52	9.233899	9.993528	9.240371	10.759629	10.006472	10.766101	8
53	9.234625	9.993507	9.241118	10.758882	10.006493	10.765375	7
54	9.235349	9.993484	9.241865	10.758135	10.006516	10.764651	6
55	9.236073	9.993462	9.242610	10.757390	10.006538	10.763927	5
56	9.236795	9.993440	9.243354	10.756646	10.006560	10.763205	4
57	9.237515	9.993418	9.244097	10.755903	10.006582	10.762485	3
58	9.238235	9.993396	9.244839	10.755161	10.006604	10.761765	2
59	9.238953	9.993374	9.245579	10.754421	10.006626	10.761047	1
60	9.239670	9.993352	9.246319	10.753681	10.006648	10.760330	0
	Sine		Tangent		Secant		Minutes

80 Degrees.

10 Degrees.

Minutes	Sine		Tang.		Secant	
0	9.239670	9.993351	9.246319	10.753081	10.006649	10.760330
1	9.240386	9.993329	9.247057	10.752943	10.006671	10.759614
2	9.241101	9.993307	9.247794	10.752806	10.006693	10.758899
3	9.241814	9.993284	9.248530	10.751470	10.006716	10.758186
4	9.242526	9.993262	9.249264	10.750736	10.006738	10.757474
5	9.243237	9.993240	9.249998	10.750002	10.006760	10.756763
6	9.243947	9.993217	9.250730	10.749270	10.006783	10.756053
7	9.244656	9.993195	9.251461	10.748539	10.006805	10.755344
8	9.245363	9.993172	9.252191	10.747809	10.006828	10.754637
9	9.246069	9.993149	9.252920	10.747080	10.006851	10.753931
10	9.246775	9.993127	9.253648	10.746352	10.006873	10.753225
11	9.247478	9.993104	9.254374	10.745626	10.006896	10.752522
12	9.248181	9.993081	9.255100	10.744900	10.006919	10.751819
13	9.248883	9.993059	9.255824	10.744176	10.006941	10.751117
14	9.249583	9.993036	9.256547	10.743453	10.006964	10.750417
15	9.250282	9.993013	9.257269	10.742731	10.006987	10.749718
16	9.250980	9.992990	9.257990	10.742010	10.007010	10.749020
17	9.251677	9.992967	9.258710	10.741290	10.007033	10.748323
18	9.252373	9.992944	9.259428	10.740572	10.007056	10.747627
19	9.253067	9.992921	9.260146	10.739854	10.007079	10.746933
20	9.253761	9.992898	9.260862	10.739138	10.007102	10.746239
21	9.254453	9.992875	9.261578	10.738422	10.007125	10.745547
22	9.255144	9.992852	9.262292	10.737708	10.007148	10.744856
23	9.255834	9.992829	9.263005	10.736995	10.007171	10.744166
24	9.256523	9.992806	9.263717	10.736283	10.007194	10.743477
25	9.257211	9.992783	9.264428	10.735572	10.007217	10.742789
26	9.257898	9.992759	9.265138	10.734862	10.007241	10.742102
27	9.258583	9.992736	9.265847	10.734153	10.007264	10.741417
28	9.259268	9.992713	9.266555	10.733445	10.007287	10.740732
29	9.259951	9.992689	9.267261	10.732739	10.007311	10.740049
30	9.260633	9.992666	9.267967	10.732033	10.007334	10.739367
		Sine		Tangent		Secant

79 Degrees.

Tangents, and Secants.

(379)

10 Degrees.

Minutes	Sine		Tang.		Secant		Minutes
30	9.260633	9.992666	9.267967	10.732033	10.007334	10.739367	30
31	9.261314	9.992643	9.268671	10.731329	10.007357	10.738686	29
32	9.261994	9.992619	9.269375	10.730625	10.007381	10.738006	28
33	9.262673	9.992596	9.270077	10.729923	10.007404	10.737327	27
34	9.263351	9.992572	9.270779	10.729221	10.007428	10.736649	26
35	9.264026	9.992549	9.271479	10.728521	10.007451	10.735973	25
36	9.264703	9.992525	9.272178	10.727822	10.007475	10.735297	24
37	9.265377	9.992501	9.272876	10.727124	10.007499	10.734623	23
38	9.266051	9.992478	9.273573	10.726427	10.007522	10.733949	22
39	9.266723	9.992454	9.274269	10.725731	10.007546	10.733277	21
40	9.267395	9.992430	9.274964	10.725036	10.007570	10.732605	20
41	9.268065	9.992406	9.275658	10.724342	10.007594	10.731935	19
42	9.268734	9.992382	9.276351	10.723649	10.007618	10.731266	18
43	9.269402	9.992358	9.277043	10.722957	10.007642	10.730598	17
44	9.270069	9.992335	9.277734	10.722266	10.007665	10.729931	16
45	9.270735	9.992311	9.278424	10.721576	10.007689	10.729265	15
46	9.271400	9.992287	9.279113	10.720887	10.007713	10.728600	14
47	9.272063	9.992263	9.279801	10.720199	10.007737	10.727937	13
48	9.272726	9.992238	9.280488	10.719512	10.007762	10.727274	12
49	9.273388	9.992214	9.281174	10.718826	10.007786	10.726612	11
50	9.274049	9.992190	9.281858	10.718142	10.007810	10.725951	10
51	9.274708	9.992166	9.282542	10.717458	10.007834	10.725292	9
52	9.275367	9.992142	9.283225	10.716775	10.007858	10.724633	8
53	9.276024	9.992117	9.283907	10.716093	10.007883	10.723976	7
54	9.276681	9.992093	9.284588	10.715412	10.007907	10.723319	6
55	9.277337	9.992069	9.285268	10.714732	10.007931	10.722663	5
56	9.277991	9.992044	9.285947	10.714053	10.007956	10.722009	4
57	9.278644	9.992020	9.286624	10.713376	10.007980	10.721351	3
58	9.279297	9.991996	9.287301	10.712699	10.008004	10.721703	2
59	9.279948	9.991971	9.287977	10.712023	10.008029	10.722055	1
60	9.280599	9.991947	9.288652	10.711348	10.008053	10.719401	0
	Sine		Tangent		Secant		Minutes

79 Degrees.

11 Degrees.

Minutes	Sine		Tang.		Secant	
0	9.280599	9.991947	9.288052	10.711348	10.008053	10.719401
1	9.281248	9.991922	9.289326	10.710674	10.008078	10.718752
2	9.281897	9.991897	9.289999	10.710001	10.008103	10.718103
3	9.282544	9.991873	9.290671	10.709329	10.008127	10.717456
4	9.283190	9.991848	9.291342	10.708658	10.008152	10.716810
5	9.283836	9.991823	9.292013	10.707987	10.008177	10.716164
6	9.284480	9.991799	9.292682	10.707318	10.008201	10.715520
7	9.285124	9.991774	9.293350	10.706650	10.008226	10.714876
8	9.285766	9.991749	9.294017	10.705983	10.008251	10.714234
9	9.286408	9.991724	9.294684	10.705316	10.008276	10.713592
10	9.287048	9.991699	9.295349	10.704651	10.008301	10.712952
11	9.287687	9.991674	9.296013	10.703987	10.008326	10.712313
12	9.288326	9.991649	9.296677	10.703323	10.008351	10.711674
13	9.288964	9.991624	9.297339	10.702661	10.008376	10.711036
14	9.289600	9.991599	9.298001	10.701999	10.008401	10.710400
15	9.290236	9.991574	9.298662	10.701338	10.008426	10.709764
16	9.290870	9.991549	9.299322	10.700678	10.008451	10.709130
17	9.291504	9.991524	9.299980	10.700020	10.008476	10.708496
18	9.292137	9.991498	9.300638	10.699362	10.008502	10.707863
19	9.292768	9.991473	9.301295	10.698705	10.008527	10.707232
20	9.293399	9.991448	9.301951	10.698049	10.008552	10.706601
21	9.294029	9.991423	9.302607	10.697393	10.008577	10.705971
22	9.294658	9.991397	9.303261	10.696739	10.008603	10.705342
23	9.295286	9.991372	9.303914	10.696086	10.008628	10.704714
24	9.295913	9.991346	9.304567	10.695433	10.008654	10.704087
25	9.296539	9.991321	9.305218	10.694782	10.008679	10.703461
26	9.297164	9.991295	9.305869	10.694131	10.008705	10.702836
27	9.297788	9.991270	9.306519	10.693481	10.008730	10.702212
28	9.298412	9.991244	9.307167	10.692833	10.008756	10.701588
29	9.299034	9.991218	9.307815	10.692185	10.008782	10.700966
30	9.299655	9.991193	9.308463	10.691537	10.008807	10.700345
		Sine		Tangent		Secant

78 Degrees.

Tangents, and Secants.

(381)

11 Degrees.

Minutes	Sine		Tang.		Secant		
30	9.299655	9.991193	9.308463	10.691537	10.008807	10.700345	30
31	9.300276	9.991167	9.309109	10.690891	10.008833	10.699724	29
32	9.300895	9.991141	9.309754	10.690246	10.008859	10.699105	28
33	9.301514	9.991115	9.310398	10.689602	10.008885	10.698486	27
34	9.302132	9.991090	9.311042	10.688958	10.008910	10.697868	26
35	9.302749	9.991064	9.311685	10.688315	10.008936	10.697251	25
36	9.303364	9.991038	9.312327	10.687673	10.008962	10.696636	24
37	9.303979	9.991012	9.312967	10.687033	10.008988	10.696021	23
38	9.304593	9.990986	9.313608	10.686392	10.009014	10.695407	22
39	9.305207	9.990960	9.314247	10.685753	10.009040	10.694793	21
40	9.305819	9.990934	9.314885	10.685115	10.009066	10.694181	20
41	9.306430	9.990908	9.315523	10.684477	10.009092	10.693570	19
42	9.307041	9.990882	9.316159	10.683841	10.009118	10.692959	18
43	9.307650	9.990855	9.316795	10.683205	10.009145	10.692350	17
44	9.308259	9.990829	9.317430	10.682570	10.009171	10.691741	16
45	9.308867	9.990803	9.318064	10.681936	10.009197	10.691133	15
46	9.309474	9.990777	9.318697	10.681303	10.009223	10.690520	14
47	9.310080	9.990750	9.319329	10.680671	10.009250	10.689920	13
48	9.310685	9.990724	9.319961	10.680039	10.009276	10.689315	12
49	9.311289	9.990697	9.320592	10.679408	10.009303	10.688711	11
50	9.311893	9.990671	9.321222	10.678778	10.009329	10.688107	10
51	9.312495	9.990644	9.321851	10.678149	10.009356	10.687505	9
52	9.313097	9.990618	9.322479	10.677521	10.009382	10.686903	8
53	9.313698	9.990591	9.323106	10.676894	10.009409	10.686302	7
54	9.314297	9.990565	9.323733	10.676267	10.009435	10.685703	6
55	9.314896	9.990538	9.324358	10.675642	10.009462	10.685104	5
56	9.315495	9.990511	9.324983	10.675017	10.009480	10.684505	4
57	9.316092	9.990485	9.325607	10.674393	10.009515	10.683908	3
58	9.316688	9.990458	9.326230	10.673770	10.009542	10.683312	2
59	9.317284	9.990431	9.326853	10.673147	10.009569	10.682716	1
60	9.317879	9.990404	9.327474	10.672526	10.009596	10.682121	0
	Sine		Tangent		Secant		Minutes

78 Degrees.

12 Degrees.

Minutes	Sine		Tang.		Secant	
0	9.317875	9.990404	9.327474	10.672526	10.009596	10.682121
1	9.318473	9.990377	9.328095	10.671905	10.009623	10.681527
2	9.319066	9.990351	9.328715	10.671285	10.009649	10.680934
3	9.319659	9.990324	9.329334	10.670666	10.009676	10.680342
4	9.320249	9.990297	9.329953	10.670047	10.009703	10.679751
5	9.320840	9.990270	9.330570	10.669430	10.009730	10.679160
6	9.321430	9.990243	9.331187	10.668813	10.009757	10.678570
7	9.322019	9.990215	9.331803	10.668197	10.009785	10.677981
8	9.322607	9.990188	9.332418	10.667582	10.009812	10.677393
9	9.323194	9.990161	9.333033	10.666967	10.009839	10.676806
10	9.323780	9.990134	9.333646	10.666354	10.009866	10.676220
11	9.324366	9.990107	9.334259	10.665741	10.009893	10.675634
12	9.324951	9.990079	9.334871	10.665129	10.009921	10.675049
13	9.325534	9.990052	9.335482	10.664518	10.009948	10.674466
14	9.326117	9.990025	9.336093	10.663907	10.009975	10.673883
15	9.326700	9.989997	9.336702	10.663293	10.010003	10.673300
16	9.327281	9.989970	9.337311	10.662689	10.010030	10.672719
17	9.327861	9.989942	9.337919	10.662081	10.010058	10.672138
18	9.328442	9.989915	9.338527	10.661473	10.010085	10.671558
19	9.329021	9.989887	9.339133	10.660867	10.010113	10.670979
20	9.329599	9.989860	9.339739	10.660261	10.010140	10.670401
21	9.330176	9.989832	9.340344	10.659656	10.010168	10.669824
22	9.330753	9.989804	9.340948	10.659052	10.010196	10.669247
23	9.331328	9.989777	9.341552	10.658448	10.010223	10.668672
24	9.331903	9.989749	9.342155	10.657845	10.010251	10.668097
25	9.332478	9.989721	9.342757	10.657243	10.010279	10.667522
26	9.333051	9.989693	9.343358	10.656642	10.010307	10.666949
27	9.333624	9.989665	9.343958	10.656042	10.010335	10.666376
28	9.334195	9.989637	9.344558	10.655442	10.010363	10.665805
29	9.334766	9.989609	9.345157	10.654843	10.010391	10.665234
30	9.335337	9.989581	9.345755	10.654245	10.010419	10.664663
	Sine		Tang.		Secant	Minutes

77 Degrees.

Tangents, and Secants.

(383)

- 12 Degrees.

Minutes	Sine		Tang.		Secant		
30	9.335337	9.989581	9.345755	10.654245	10.010419	10.664663	30
31	9.335906	9.989553	9.346353	10.653647	10.010447	10.664094	29
32	9.336475	9.989525	9.346949	10.653051	10.010475	10.663525	28
33	9.337043	9.989497	9.347545	10.652455	10.010503	10.662957	27
34	9.337610	9.989469	9.348141	10.651859	10.010531	10.662390	26
35	9.338176	9.989441	9.348735	10.651265	10.010559	10.661824	25
36	9.338742	9.989413	9.349329	10.650671	10.010587	10.661258	24
37	9.339306	9.989384	9.349922	10.650078	10.010616	10.660694	23
38	9.339871	9.989356	9.350514	10.649486	10.010644	10.660129	22
39	9.340434	9.989328	9.351106	10.648894	10.010672	10.659566	21
40	9.340996	9.989299	9.351697	10.648303	10.010701	10.659004	20
41	9.341558	9.989271	9.352287	10.647713	10.010729	10.658442	19
42	9.342119	9.989243	9.352876	10.647124	10.010757	10.657881	18
43	9.342679	9.989214	9.353465	10.646535	10.010786	10.657321	17
44	9.343239	9.989186	9.354053	10.645947	10.010814	10.656761	16
45	9.343797	9.989157	9.354640	10.645360	10.010843	10.656203	15
46	9.344355	9.989128	9.355227	10.644773	10.010872	10.655645	14
47	9.344912	9.989100	9.355813	10.644187	10.010900	10.655088	13
48	9.345469	9.989071	9.356398	10.643602	10.010929	10.654531	12
49	9.346024	9.989042	9.356982	10.643018	10.010958	10.653976	11
50	9.346579	9.989014	9.357566	10.642434	10.010986	10.653421	10
51	9.347134	9.988985	9.358149	10.641851	10.011015	10.652866	9
52	9.347687	9.988956	9.358731	10.641269	10.011044	10.652313	8
53	9.348240	9.988927	9.359313	10.640687	10.011073	10.651760	7
54	9.348792	9.988898	9.359893	10.640107	10.011102	10.651208	6
55	9.349343	9.988869	9.360474	10.639526	10.011131	10.650657	5
56	9.349893	9.988840	9.361053	10.638947	10.011160	10.650107	4
57	9.350443	9.988811	9.361632	10.638368	10.011189	10.649557	3
58	9.350992	9.988782	9.362210	10.637790	10.011218	10.649008	2
59	9.351540	9.988753	9.362787	10.637213	10.011247	10.648460	1
60	9.352088	9.988724	9.363364	10.636636	10.011276	10.647912	c
	Sine		Tangent		Secant		Minutes

77 Degrees.

13 Degrees.

Minutes	Sine	Tang.	Secant	Minutes
1	9.35208	9.36336	10.63003	60
2	9.35263	9.36394	10.63060	59
3	9.35318	9.36451	10.63117	58
4	9.35372	9.36509	10.63174	57
5	9.35427	9.36566	10.63231	56
6	9.35481	9.36623	10.63288	55
7	9.35535	9.36681	10.63345	54
8	9.35590	9.36738	10.63402	53
9	9.35644	9.36795	10.63459	52
10	9.35698	9.36852	10.63516	51
11	9.35752	9.36909	10.63573	50
12	9.35806	9.36966	10.63630	49
13	9.35860	9.37023	10.63687	48
14	9.35914	9.37079	10.63744	47
15	9.35967	9.37136	10.63801	46
16	9.36021	9.37193	10.63858	45
17	9.36075	9.37250	10.63915	44
18	9.36128	9.37306	10.63972	43
19	9.36182	9.37362	10.64029	42
20	9.36235	9.37419	10.64086	41
21	9.36289	9.37475	10.64143	40
22	9.36342	9.37531	10.64200	39
23	9.36395	9.37588	10.64257	38
24	9.36448	9.37644	10.64314	37
25	9.36501	9.37700	10.64371	36
26	9.36554	9.37756	10.64428	35
27	9.36607	9.37812	10.64485	34
28	9.36660	9.37868	10.64542	33
29	9.36713	9.37923	10.64599	32
30	9.36765	9.37979	10.64656	31
31	9.36818	9.38034	10.64713	30
	Sine	Tang.	Secant	Minutes

76 Degrees.

Tangents, and Secants.

(385)

13 Degrees.

Minutes	Sine		Tang.		Secant		
30	9.368185	9.987831	9.380354	10.619646	10.012169	10.631815	30
31	9.368711	9.987801	9.380910	10.619090	10.012199	10.631289	29
32	9.369236	9.987771	9.381465	10.618535	10.012229	10.630764	28
33	9.369761	9.987740	9.382020	10.617980	10.012260	10.630239	27
34	9.370285	9.987710	9.382575	10.617425	10.012290	10.629715	26
35	9.370808	9.987679	9.383129	10.616871	10.012321	10.629192	25
36	9.371330	9.987649	9.383682	10.616318	10.012351	10.628670	24
37	9.371852	9.987618	9.384234	10.615766	10.012382	10.628148	23
38	9.372373	9.987588	9.384786	10.615214	10.012412	10.627627	22
39	9.372894	9.987557	9.385337	10.614663	10.012443	10.627106	21
40	9.373414	9.987526	9.385888	10.614112	10.012474	10.626586	20
41	9.373933	9.987495	9.386438	10.613562	10.012505	10.626067	19
42	9.374452	9.987465	9.386987	10.613013	10.012535	10.625548	18
43	9.374970	9.987434	9.387536	10.612464	10.012566	10.625030	17
44	9.375487	9.987403	9.388084	10.611916	10.012597	10.624513	16
45	9.376003	9.987372	9.388631	10.611369	10.012628	10.623997	15
46	9.376519	9.987341	9.389178	10.610822	10.012659	10.623481	14
47	9.377035	9.987310	9.389724	10.610276	10.012690	10.622965	13
48	9.377549	9.987279	9.390270	10.609730	10.012721	10.622451	12
49	9.378063	9.987248	9.390815	10.609185	10.012752	10.621937	11
50	9.378577	9.987217	9.391359	10.608641	10.012783	10.621423	10
51	9.379089	9.987186	9.391903	10.608097	10.012814	10.620911	9
52	9.379601	9.987155	9.392447	10.607553	10.012845	10.620399	8
53	9.380113	9.987124	9.392989	10.607011	10.012876	10.619887	7
54	9.380624	9.987092	9.393531	10.606469	10.012908	10.619376	6
55	9.381134	9.987061	9.394073	10.605927	10.012939	10.618866	5
56	9.381643	9.987030	9.394614	10.605386	10.012970	10.618357	4
57	9.382152	9.986998	9.395154	10.604846	10.013002	10.617848	3
58	9.382660	9.986967	9.395693	10.604307	10.013033	10.617340	2
59	9.383168	9.986936	9.396233	10.603767	10.013064	10.616832	1
60	9.383675	9.986904	9.396771	10.603229	10.013096	10.616325	0
	Sine		Tang.		Secant		Minutes

76 Degrees.

B b

14 Degrees.

Minutes	Sine	Tang.	Secant	Minutes			
0	9.303075	9.986904	9.396771	10.603229	10.013096	10.616325	60
1	9.384181	9.986873	9.397309	10.602691	10.013127	10.615819	59
2	9.384687	9.986841	9.397846	10.602154	10.013155	10.615313	58
3	9.385192	9.986809	9.398383	10.601617	10.013191	10.614808	57
4	9.385697	9.986778	9.398919	10.601081	10.013222	10.614303	56
5	9.386201	9.986746	9.399455	10.600545	10.013254	10.613799	55
6	9.386704	9.986714	9.399990	10.600010	10.013286	10.613296	54
7	9.387207	9.986683	9.400524	10.599476	10.013317	10.612793	53
8	9.387709	9.986651	9.401058	10.598942	10.013349	10.612291	52
9	9.388210	9.986619	9.401591	10.598409	10.013381	10.611790	51
10	9.388711	9.986587	9.402124	10.597876	10.013413	10.611289	50
11	9.389211	9.986555	9.402656	10.597344	10.013445	10.610789	49
12	9.389711	9.986523	9.403187	10.596813	10.013477	10.610289	48
13	9.390210	9.986491	9.403718	10.596282	10.013509	10.609790	47
14	9.390708	9.986459	9.404249	10.595751	10.013541	10.609292	46
15	9.391206	9.986427	9.404778	10.595222	10.013573	10.608794	45
16	9.391703	9.986395	9.405308	10.594692	10.013605	10.608297	44
17	9.392199	9.986363	9.405836	10.594164	10.013637	10.607801	43
18	9.392695	9.986331	9.406364	10.593636	10.013669	10.607305	42
19	9.393190	9.986299	9.406892	10.593108	10.013701	10.606810	41
20	9.393685	9.986266	9.407419	10.592581	10.013734	10.606315	40
21	9.394179	9.986234	9.407945	10.592055	10.013766	10.605821	39
22	9.394673	9.986202	9.408471	10.591529	10.013798	10.605327	38
23	9.395166	9.986169	9.408997	10.591003	10.013831	10.604834	37
24	9.395658	9.986137	9.409521	10.590479	10.013863	10.604342	36
25	9.396150	9.986104	9.410045	10.589955	10.013896	10.603850	35
26	9.396641	9.986072	9.410569	10.589431	10.013928	10.603359	34
27	9.397132	9.986039	9.411092	10.588908	10.013961	10.602868	33
28	9.397621	9.986007	9.411615	10.588385	10.013993	10.602379	32
29	9.398111	9.985974	9.412137	10.587863	10.014026	10.601889	31
30	9.398600	9.985942	9.412658	10.587342	10.014058	10.601400	30
	Sine		Tang.		Secant		Minutes

75 Degrees.

Tangents, and Secants.

(387)

14 Degrees.

Minutes	Sine	Tang.	Secant				Minutes
30	9.398600	9.985942	9.412651	10.587341	10.014050	10.601400	30
31	9.399088	9.985909	9.413179	10.586821	10.014091	10.600912	29
32	9.399575	9.985876	9.413699	10.586301	10.014124	10.600425	28
33	9.400062	9.985843	9.414219	10.585781	10.014157	10.599938	27
34	9.400549	9.985811	9.414738	10.585262	10.014189	10.599451	26
35	9.401035	9.985778	9.415257	10.584743	10.014222	10.598965	25
36	9.401520	9.985745	9.415775	10.584225	10.014255	10.598480	24
37	9.402005	9.985712	9.416293	10.583707	10.014288	10.597995	23
38	9.402489	9.985679	9.416810	10.583190	10.014321	10.597511	22
39	9.402972	9.985646	9.417326	10.582674	10.014354	10.597028	21
40	9.403455	9.985613	9.417842	10.582158	10.014387	10.596545	20
41	9.403938	9.985580	9.418358	10.581642	10.014420	10.596062	19
42	9.404420	9.985547	9.418873	10.581127	10.014453	10.595580	18
43	9.404901	9.985513	9.419387	10.580613	10.014487	10.595099	17
44	9.405382	9.985480	9.419901	10.580099	10.014520	10.594618	16
45	9.405862	9.985447	9.420415	10.579585	10.014553	10.594138	15
46	9.406341	9.985414	9.420927	10.579073	10.014586	10.593659	14
47	9.406820	9.985380	9.421440	10.578560	10.014620	10.593180	13
48	9.407299	9.985347	9.421951	10.578049	10.014653	10.592701	12
49	9.407777	9.985314	9.422463	10.577537	10.014686	10.592223	11
50	9.408254	9.985280	9.422973	10.577027	10.014720	10.591746	10
51	9.408731	9.985247	9.423484	10.576516	10.014753	10.591269	9
52	9.409207	9.985213	9.423993	10.576007	10.014787	10.590793	8
53	9.409682	9.985180	9.424503	10.575497	10.014820	10.590318	7
54	9.410157	9.985146	9.425011	10.574989	10.014854	10.589843	6
55	9.410632	9.985112	9.425519	10.574481	10.014888	10.589368	5
56	9.411106	9.985079	9.426027	10.573973	10.014921	10.588894	4
57	9.411579	9.985045	9.426534	10.573466	10.014955	10.588421	3
58	9.412052	9.985011	9.427041	10.572959	10.014989	10.587948	2
59	9.412524	9.984978	9.427547	10.572453	10.015022	10.587476	1
60	9.412996	9.984944	9.428052	10.571948	10.015056	10.587004	0
	Sine		Tang.		Secant		Minutes

75 Degrees.

(388)

A Table of Artificial Sines,

15 Degrees.

Minutes	Sine		Tang.		Secant	
0	9.412996	9.984944	9.428052	10.571948	10.015056	10.587004 60
1	9.413467	9.984910	9.428557	10.571443	10.015090	10.586533 59
2	9.413938	9.984876	9.429062	10.570938	10.015124	10.586062 58
3	9.414408	9.984842	9.429566	10.570434	10.015158	10.585592 57
4	9.414878	9.984808	9.430070	10.569930	10.015192	10.585122 56
5	9.415347	9.984774	9.430573	10.569427	10.015226	10.584653 55
6	9.415815	9.984740	9.431075	10.568925	10.015260	10.584185 54
7	9.416283	9.984706	9.431577	10.568423	10.015294	10.583717 53
8	9.416751	9.984672	9.432079	10.567921	10.015328	10.583249 52
9	9.417217	9.984637	9.432580	10.567420	10.015363	10.582783 51
10	9.417684	9.984603	9.433080	10.566920	10.015397	10.582316 50
11	9.418149	9.984569	9.433580	10.566420	10.015431	10.581851 49
12	9.418615	9.984535	9.434080	10.565920	10.015465	10.581385 48
13	9.419079	9.984500	9.434579	10.565421	10.015500	10.580921 47
14	9.419544	9.984466	9.435078	10.564922	10.015534	10.580456 46
15	9.420007	9.984432	9.435576	10.564424	10.015568	10.579993 45
16	9.420470	9.984397	9.436073	10.563927	10.015603	10.579530 44
17	9.420933	9.984363	9.436570	10.563430	10.015637	10.579067 43
18	9.421395	9.984328	9.437067	10.562933	10.015672	10.578605 42
19	9.421857	9.984293	9.437563	10.562437	10.015707	10.578143 41
20	9.422318	9.984259	9.438059	10.561941	10.015741	10.577682 40
21	9.422778	9.984224	9.438554	10.561446	10.015776	10.577223 39
22	9.423238	9.984189	9.439048	10.560952	10.015811	10.576762 38
23	9.423697	9.984155	9.439543	10.560457	10.015845	10.576303 37
24	9.424156	9.984120	9.440036	10.559964	10.015880	10.575844 36
25	9.424615	9.984085	9.440529	10.559471	10.015915	10.575385 35
26	9.425073	9.984050	9.441022	10.558978	10.015950	10.574927 34
27	9.425530	9.984015	9.441514	10.558486	10.015985	10.574470 33
28	9.425987	9.983981	9.442006	10.557994	10.016019	10.574013 32
29	9.426443	9.983946	9.442497	10.557503	10.016054	10.573557 31
30	9.426899	9.983910	9.442988	10.557012	10.016090	10.573101 30
		Sine		Tang.		Secant

74 Degrees.

15 Degrees.

Minutes	Sine		Tang.		Secant		Minutes
30	9.426899	9.983910	9.442988	10.557012	10.016090	10.573101	30
31	9.427354	9.983875	9.443479	10.556521	10.016125	10.572646	29
32	9.427809	9.983840	9.443968	10.556032	10.016160	10.572191	28
33	9.428263	9.983805	9.444458	10.555542	10.016195	10.571737	27
34	9.428717	9.983770	9.444947	10.555051	10.016230	10.571283	26
35	9.429170	9.983735	9.445435	10.554565	10.016265	10.570830	25
36	9.429623	9.983700	9.445923	10.554077	10.016300	10.570377	24
37	9.430075	9.983664	9.446411	10.553589	10.016336	10.569925	23
38	9.430527	9.983629	9.446898	10.553102	10.016371	10.569473	22
39	9.430978	9.983594	9.447384	10.552616	10.016406	10.569022	21
40	9.431429	9.983558	9.447870	10.552130	10.016442	10.568571	20
41	9.431879	9.983523	9.448356	10.551644	10.016477	10.568121	19
42	9.432328	9.983487	9.448841	10.551159	10.016513	10.567672	18
43	9.432778	9.983452	9.449326	10.550674	10.016548	10.567222	17
44	9.433226	9.983416	9.449810	10.550190	10.016584	10.566774	16
45	9.433675	9.983380	9.450294	10.549706	10.016620	10.566325	15
46	9.434122	9.983345	9.450777	10.549223	10.016655	10.565878	14
47	9.434569	9.983309	9.451260	10.548740	10.016691	10.565431	13
48	9.435016	9.983273	9.451743	10.548257	10.016727	10.564984	12
49	9.435462	9.983238	9.452225	10.547775	10.016762	10.564538	11
50	9.435908	9.983202	9.452706	10.547294	10.016798	10.564092	10
51	9.436353	9.983166	9.453187	10.546813	10.016834	10.563647	9
52	9.436798	9.983130	9.453668	10.546332	10.016870	10.563202	8
53	9.437242	9.983094	9.454148	10.545852	10.016906	10.562758	7
54	9.437686	9.983058	9.454628	10.545372	10.016942	10.562314	6
55	9.438129	9.983022	9.455107	10.544893	10.016978	10.561871	5
56	9.438572	9.982986	9.455586	10.544414	10.017014	10.561428	4
57	9.439014	9.982950	9.456064	10.543936	10.017050	10.560986	3
58	9.439456	9.982914	9.456542	10.543458	10.017086	10.560544	2
59	9.439897	9.982878	9.457019	10.542981	10.017122	10.560103	1
60	9.440338	9.982842	9.457496	10.542504	10.017158	10.559662	0
	Sine		Tangent		Secant		Minutes

74 Degrees.

B b 3

(390) A Table of Artificial Sines;

16 Degrees.

Minutes	Sine		Tang.		Secant	
0	9.440338	9.982842	9.457496	10.54250	10.017158	10.559662
1	9.440778	9.982805	9.457973	10.542027	10.017195	10.559222
2	9.441218	9.982769	9.458445	10.541551	10.017231	10.558782
3	9.441658	9.982733	9.458925	10.541075	10.017267	10.558342
4	9.442096	9.982696	9.459400	10.540600	10.017304	10.557904
5	9.442535	9.982660	9.459875	10.540125	10.017340	10.557465
6	9.442973	9.982624	9.460349	10.539651	10.017376	10.557027
7	9.443410	9.982587	9.460823	10.539177	10.017413	10.556590
8	9.443847	9.982551	9.461297	10.538703	10.017449	10.556153
9	9.444284	9.982514	9.461770	10.538230	10.017486	10.555716
10	9.444720	9.982477	9.462242	10.537758	10.017523	10.555280
11	9.445155	9.982441	9.462714	10.537286	10.017559	10.554845
12	9.445590	9.982404	9.463186	10.536814	10.017596	10.554410
13	9.446025	9.982367	9.463658	10.536342	10.017633	10.553975
14	9.446459	9.982331	9.464128	10.535872	10.017669	10.553541
15	9.446893	9.982294	9.464599	10.535401	10.017706	10.553107
16	9.447326	9.982257	9.465069	10.534931	10.017743	10.552674
17	9.447759	9.982220	9.465539	10.534461	10.017780	10.552241
18	9.448191	9.982183	9.466008	10.533992	10.017817	10.551809
19	9.448623	9.982146	9.466476	10.533524	10.017854	10.551377
20	9.449054	9.982109	9.466945	10.533055	10.017891	10.550946
21	9.449485	9.982072	9.467413	10.532587	10.017928	10.550515
22	9.449915	9.982035	9.467880	10.532120	10.017965	10.550085
23	9.450345	9.981998	9.468347	10.531653	10.018002	10.549655
24	9.450775	9.981961	9.468814	10.531186	10.018039	10.549225
25	9.451204	9.981924	9.469280	10.530720	10.018076	10.548796
26	9.451632	9.981886	9.469746	10.530254	10.018114	10.548368
27	9.452060	9.981849	9.470211	10.529789	10.018151	10.547940
28	9.452488	9.981812	9.470676	10.529324	10.018188	10.547512
29	9.452915	9.981774	9.471141	10.528859	10.018226	10.547085
30	9.453342	9.981737	9.471605	10.528395	10.018263	10.546658
	Sine		Tangent		Secant	Minutes

73 Degrees.

Tangents, and Secants. (391)

16 Degrees.

Minutes	Sine		Tang.		Secant		
30	9.453342	9.981737	9.471605	10.528395	10.018203	10.540658	30
31	9.453768	9.981699	9.472068	10.527932	10.018301	10.546232	29
32	9.454194	9.981662	9.472532	10.527468	10.018338	10.545806	28
33	9.454619	9.981625	9.472995	10.527005	10.018375	10.545381	27
34	9.455044	9.981587	9.473457	10.526543	10.018413	10.544956	26
35	9.455469	9.981549	9.473919	10.526081	10.018451	10.544531	25
36	9.455893	9.981512	9.474381	10.525619	10.018488	10.544107	24
37	9.456316	9.981474	9.474842	10.525158	10.018526	10.543684	23
38	9.456739	9.981436	9.475303	10.524697	10.018564	10.543261	22
39	9.457162	9.981399	9.475763	10.524237	10.018601	10.542838	21
40	9.457584	9.981361	9.476223	10.523777	10.018639	10.542416	20
41	9.458006	9.981323	9.476683	10.523317	10.018677	10.541994	19
42	9.458427	9.981285	9.477142	10.522858	10.018715	10.541573	18
43	9.458848	9.981247	9.477601	10.522399	10.018753	10.541152	17
44	9.459268	9.981209	9.478059	10.521941	10.018791	10.540732	16
45	9.459688	9.981171	9.478517	10.521483	10.018829	10.540312	15
46	9.460108	9.981133	9.478975	10.521025	10.018867	10.539892	14
47	9.460527	9.981095	9.479432	10.520568	10.018905	10.539473	13
48	9.460946	9.981057	9.479889	10.520111	10.018943	10.539054	12
49	9.461364	9.981019	9.480345	10.519655	10.018981	10.538636	11
50	9.461782	9.980980	9.480801	10.519199	10.019020	10.538218	10
51	9.462199	9.980942	9.481257	10.518743	10.019058	10.537801	9
52	9.462616	9.980904	9.481712	10.518288	10.019096	10.537384	8
53	9.463032	9.980866	9.482167	10.517833	10.019134	10.536968	7
54	9.463448	9.980827	9.482621	10.517379	10.019173	10.536552	6
55	9.463864	9.980789	9.483075	10.516925	10.019211	10.536136	5
56	9.464279	9.980751	9.483529	10.516471	10.019249	10.535721	4
57	9.464694	9.980712	9.483982	10.516018	10.019288	10.535306	3
58	9.465108	9.980673	9.484435	10.515565	10.019327	10.534892	2
59	9.465522	9.980635	9.484887	10.515113	10.019365	10.534478	1
60	9.465935	9.980596	9.485339	10.514661	10.019404	10.534065	0
	Sine		Tangent		Secant		Minutes

73 Degrees.

17 Degrees.

Minutes	Sine		Tang.		Secant		
0	9.465935	9.980590	9.485339	10.514661	10.019404	10.534065	50
1	9.466348	9.980558	9.485791	10.514209	10.019442	10.533652	59
2	9.466761	9.980519	9.486242	10.513758	10.019481	10.533239	58
3	9.467173	9.980480	9.486693	10.513307	10.019520	10.532827	57
4	9.467585	9.980441	9.487143	10.512857	10.019559	10.532415	56
5	9.467996	9.980403	9.487593	10.512407	10.019597	10.532004	55
6	9.468407	9.980364	9.488043	10.511957	10.019636	10.531593	54
7	9.468817	9.980325	9.488492	10.511506	10.019675	10.531183	53
8	9.469227	9.980286	9.488941	10.511059	10.019714	10.530773	52
9	9.469637	9.980247	9.489390	10.510610	10.019753	10.530363	51
10	9.470046	9.980208	9.489838	10.510162	10.019792	10.529954	50
11	9.470455	9.980169	9.490286	10.509714	10.019831	10.529545	49
12	9.470863	9.980130	9.490733	10.509267	10.019870	10.529137	48
13	9.471271	9.980091	9.491180	10.508820	10.019909	10.528729	47
14	9.471678	9.980052	9.491627	10.508373	10.019948	10.528322	46
15	9.472086	9.980012	9.492073	10.507927	10.019988	10.527914	45
16	9.472492	9.979973	9.492519	10.507481	10.020027	10.527508	44
17	9.472898	9.979934	9.492965	10.507035	10.020066	10.527102	43
18	9.473304	9.979895	9.493410	10.506590	10.020105	10.526696	42
19	9.473710	9.979855	9.493854	10.506146	10.020145	10.526290	41
20	9.474115	9.979816	9.494299	10.505701	10.020184	10.525885	40
21	9.474519	9.979776	9.494743	10.505257	10.020224	10.525481	39
22	9.474923	9.979737	9.495186	10.504814	10.020263	10.525077	38
23	9.475327	9.979697	9.495630	10.504370	10.020303	10.524673	37
24	9.475730	9.979658	9.496073	10.503927	10.020342	10.524270	36
25	9.476133	9.979618	9.496515	10.503485	10.020382	10.523867	35
26	9.476536	9.979578	9.496957	10.503043	10.020422	10.523464	34
27	9.476938	9.979539	9.497399	10.502601	10.020461	10.523062	33
28	9.477340	9.979499	9.497841	10.502159	10.020501	10.522660	32
29	9.477741	9.979459	9.498282	10.501718	10.020541	10.522259	31
30	9.478142	9.979419	9.498722	10.501278	10.020581	10.521858	30
	Sine		Tangent		Secant		Minutes

72 Degrees.

Tangents, and Secants.

(393)

17 Degrees.

Minutes	Sine		Tang.		Secant		Minutes
30	9.478142	9.979419	9.498722	10.501278	10.020581	10.521858	30
31	9.478542	9.979380	9.499163	10.500837	10.020620	10.521458	29
32	9.478942	9.979340	9.499603	10.500397	10.020660	10.521058	28
33	9.479342	9.979300	9.500042	10.499958	10.020700	10.520658	27
34	9.479741	9.979260	9.500481	10.499519	10.020740	10.520259	26
35	9.480140	9.979220	9.500920	10.499080	10.020780	10.519860	25
36	9.480538	9.979180	9.501359	10.498641	10.020820	10.519462	24
37	9.480937	9.979140	9.501797	10.498203	10.020860	10.519063	23
38	9.481334	9.979100	9.502235	10.497765	10.020900	10.518666	22
39	9.481731	9.979059	9.502672	10.497328	10.020941	10.518269	21
40	9.482128	9.979019	9.503109	10.496891	10.020981	10.517872	20
41	9.482525	9.978979	9.503546	10.496454	10.021021	10.517475	19
42	9.482921	9.978939	9.503982	10.496018	10.021061	10.517079	18
43	9.483316	9.978898	9.504418	10.495582	10.021102	10.516684	17
44	9.483712	9.978858	9.504854	10.495146	10.021142	10.516288	16
45	9.484107	9.978817	9.505289	10.494711	10.021183	10.515893	15
46	9.484501	9.978777	9.505724	10.494276	10.021223	10.515499	14
47	9.484895	9.978736	9.506159	10.493841	10.021264	10.515105	13
48	9.485289	9.978696	9.506593	10.493407	10.021304	10.514711	12
49	9.485682	9.978655	9.507027	10.492973	10.021345	10.514318	11
50	9.486075	9.978615	9.507460	10.492540	10.021385	10.513925	10
51	9.486467	9.978574	9.507893	10.492107	10.021426	10.513533	9
52	9.486859	9.978533	9.508326	10.491674	10.021467	10.513141	8
53	9.487251	9.978493	9.508759	10.491241	10.021507	10.512749	7
54	9.487643	9.978452	9.509191	10.490809	10.021548	10.512357	6
55	9.488033	9.978411	9.509622	10.490378	10.021589	10.511967	5
56	9.488424	9.978370	9.510054	10.489946	10.021630	10.511576	4
57	9.488814	9.978329	9.510485	10.489515	10.021671	10.511186	3
58	9.489204	9.978288	9.510916	10.489084	10.021712	10.510796	2
59	9.489593	9.978247	9.511346	10.488654	10.021753	10.510407	1
60	9.489982	9.978206	9.511776	10.488224	10.021794	10.510018	C
	Sine		Tangent		Secant		Minutes

72 Degrees.

18 Degrees.

Minutes	Sine		Tang.		Secant	
0	9.489982	9.978200	9.511776	10.488224	10.021794	10.510018
1	9.490371	9.978165	9.512206	10.487794	10.021835	10.509629
2	9.490759	9.978124	9.512635	10.487365	10.021876	10.509241
3	9.491147	9.978083	9.513064	10.486936	10.021917	10.508853
4	9.491534	9.978042	9.513493	10.486507	10.021958	10.508466
5	9.491922	9.978001	9.513921	10.486079	10.021999	10.508078
6	9.492308	9.977959	9.514349	10.485651	10.022041	10.507692
7	9.492695	9.977918	9.514777	10.485223	10.022082	10.507305
8	9.493081	9.977878	9.515204	10.484796	10.022122	10.506919
9	9.493466	9.977835	9.515631	10.484369	10.022165	10.506534
10	9.493851	9.977794	9.516057	10.483943	10.022206	10.506149
11	9.494236	9.977752	9.516484	10.483516	10.022248	10.505764
12	9.494620	9.977711	9.516910	10.483090	10.022289	10.505380
13	9.495005	9.977669	9.517335	10.482665	10.022331	10.504995
14	9.495388	9.977628	9.517761	10.482239	10.022372	10.504612
15	9.495772	9.977586	9.518185	10.481815	10.022414	10.504228
16	9.496154	9.977544	9.518610	10.481390	10.022456	10.503846
17	9.496537	9.977503	9.519034	10.480966	10.022497	10.503463
18	9.496919	9.977461	9.519458	10.480542	10.022539	10.503081
19	9.497301	9.977419	9.519882	10.480118	10.022581	10.502699
20	9.497682	9.977377	9.520305	10.479695	10.022623	10.502318
21	9.498063	9.977335	9.520728	10.479272	10.022665	10.501937
22	9.498444	9.977293	9.521151	10.478849	10.022707	10.501556
23	9.498824	9.977251	9.521573	10.478427	10.022749	10.501176
24	9.499204	9.977209	9.521995	10.478005	10.022791	10.500796
25	9.499584	9.977167	9.522417	10.477583	10.022833	10.500416
26	9.499963	9.977125	9.522838	10.477162	10.022875	10.500037
27	9.500342	9.977083	9.523259	10.476741	10.022917	10.499658
28	9.500721	9.977041	9.523679	10.476321	10.022959	10.499279
29	9.501099	9.976999	9.524100	10.475900	10.023001	10.498901
30	9.501476	9.976957	9.524520	10.475480	10.023043	10.498524
	Sine		Tangent		Secant	Minutes

71 Degrees.

Tangents, and Secants.

(395)

18 Degrees.

Minutes	Sine		Tang.		Secant		Minutes
30	9.501476	9.976957	9.524520	10.475480	10.023043	10.498524	30
31	9.501854	9.976914	9.524939	10.475061	10.023086	10.498146	29
32	9.502231	9.976872	9.525359	10.474641	10.023128	10.497769	28
33	9.502607	9.976830	9.525778	10.474222	10.023170	10.497393	27
34	9.502984	9.976787	9.526197	10.473803	10.023213	10.497016	26
35	9.503360	9.976745	9.526615	10.473385	10.023255	10.496640	25
36	9.503735	9.976702	9.527033	10.472967	10.023298	10.496265	24
37	9.504110	9.976660	9.527451	10.472549	10.023340	10.495890	23
38	9.504485	9.976617	9.527868	10.472132	10.023383	10.495515	22
39	9.504860	9.976574	9.528285	10.471715	10.023426	10.495140	21
40	9.505234	9.976532	9.528702	10.471298	10.023468	10.494766	20
41	9.505608	9.976489	9.529119	10.470881	10.023511	10.494392	19
42	9.505981	9.976446	9.529535	10.470465	10.023554	10.494019	18
43	9.506354	9.976404	9.529950	10.470050	10.023596	10.493646	17
44	9.506727	9.976361	9.530366	10.469634	10.023639	10.493273	16
45	9.507099	9.976318	9.530781	10.469219	10.023682	10.492901	15
46	9.507471	9.976275	9.531196	10.468804	10.023725	10.492529	14
47	9.507843	9.976232	9.531611	10.468389	10.023768	10.492157	13
48	9.508214	9.976189	9.532025	10.467975	10.023811	10.491786	12
49	9.508585	9.976146	9.532439	10.467561	10.023854	10.491415	11
50	9.508956	9.976103	9.532853	10.467147	10.023897	10.491044	10
51	9.509326	9.976060	9.533266	10.466734	10.023940	10.490674	9
52	9.509696	9.976017	9.533679	10.466321	10.023983	10.490304	8
53	9.510065	9.975974	9.534092	10.465908	10.024026	10.489935	7
54	9.510434	9.975930	9.534504	10.465496	10.024070	10.489566	6
55	9.510803	9.975887	9.534916	10.465084	10.024113	10.489197	5
56	9.511172	9.975844	9.535328	10.464672	10.024156	10.488828	4
57	9.511540	9.975800	9.535739	10.464261	10.024200	10.488460	3
58	9.511907	9.975757	9.536150	10.463850	10.024243	10.488093	2
59	9.512275	9.975713	9.536561	10.463439	10.024287	10.487725	1
60	9.512642	9.975670	9.536972	10.463028	10.024330	10.487358	c
	Sine		Tangent		Secant		Minutes

71 Degrees.

19 Degrees.

Minutes	Sine		Tang.		Secant	
0	9.512642	9.975670	9.530972	10.463028	10.024330	10.487358
1	9.513009	9.975626	9.537382	10.462618	10.024374	10.486991
2	9.513375	9.975583	9.537792	10.462208	10.024417	10.486625
3	9.513741	9.975539	9.538202	10.461798	10.024461	10.486259
4	9.514107	9.975496	9.538611	10.461389	10.024504	10.485893
5	9.514472	9.975452	9.539020	10.460980	10.024548	10.485528
6	9.514837	9.975408	9.539429	10.460571	10.024592	10.485163
7	9.515202	9.975365	9.539837	10.460163	10.024635	10.484798
8	9.515566	9.975321	9.540245	10.459755	10.024679	10.484434
9	9.515930	9.975277	9.540653	10.459347	10.024723	10.484070
10	9.516294	9.975233	9.541061	10.458939	10.024767	10.483706
11	9.516657	9.975189	9.541468	10.458532	10.024811	10.483343
12	9.517020	9.975145	9.541875	10.458125	10.024855	10.482980
13	9.517382	9.975101	9.542281	10.457719	10.024899	10.482618
14	9.517745	9.975057	9.542688	10.457312	10.024943	10.482255
15	9.518107	9.975013	9.543094	10.456906	10.024987	10.481893
16	9.518468	9.974969	9.543499	10.456501	10.025031	10.481532
17	9.518829	9.974925	9.543905	10.456095	10.025075	10.481171
18	9.519190	9.974880	9.544310	10.455690	10.025120	10.480810
19	9.519551	9.974836	9.544715	10.455285	10.025164	10.480449
20	9.519911	9.974792	9.545119	10.454881	10.025208	10.480089
21	9.520271	9.974747	9.545524	10.454476	10.025253	10.479729
22	9.520631	9.974703	9.545928	10.454072	10.025297	10.479369
23	9.520990	9.974659	9.546331	10.453669	10.025341	10.479010
24	9.521349	9.974614	9.546735	10.453265	10.025386	10.478651
25	9.521707	9.974570	9.547138	10.452862	10.025430	10.478293
26	9.522066	9.974525	9.547540	10.452460	10.025475	10.477934
27	9.522423	9.974481	9.547943	10.452057	10.025519	10.477577
28	9.522781	9.974436	9.548345	10.451655	10.025564	10.477219
29	9.523138	9.974391	9.548747	10.451253	10.025609	10.476862
30	9.523495	9.974347	9.549149	10.450851	10.025653	10.476505
	Sine		Tangent		Secant	Minutes

70 Degrees.

19 Degrees.

Minutes	Sine		Tang.		Secant		
30	9.523495	9.974347	9.549149	10.440857	10.025653	10.476505	30
31	9.523852	9.974302	9.549550	10.440450	10.025698	10.476148	29
32	9.524208	9.974257	9.549951	10.440049	10.025743	10.475792	28
33	9.524564	9.974212	9.550352	10.449648	10.025788	10.475436	27
34	9.524920	9.974167	9.550752	10.449248	10.025833	10.475080	26
35	9.525275	9.974122	9.551152	10.448848	10.025878	10.474725	25
36	9.525630	9.974077	9.551552	10.448448	10.025923	10.474370	24
37	9.525984	9.974032	9.551952	10.448048	10.025968	10.474016	23
38	9.526339	9.973987	9.552351	10.447649	10.026013	10.473661	22
39	9.526693	9.973942	9.552750	10.447250	10.026058	10.473307	21
40	9.527046	9.973897	9.553149	10.446851	10.026103	10.472954	20
41	9.527400	9.973852	9.553548	10.446452	10.026148	10.472600	19
42	9.527753	9.973807	9.553946	10.446054	10.026193	10.472247	18
43	9.528105	9.973761	9.554344	10.445656	10.026239	10.471895	17
44	9.528458	9.973716	9.554741	10.445259	10.026284	10.471542	16
45	9.528810	9.973671	9.555139	10.444861	10.026329	10.471190	15
46	9.529161	9.973625	9.555536	10.444464	10.026375	10.470839	14
47	9.529513	9.973580	9.555933	10.444067	10.026420	10.470487	13
48	9.529864	9.973535	9.556329	10.443671	10.026465	10.470136	12
49	9.530215	9.973489	9.556725	10.443275	10.026511	10.469785	11
50	9.530565	9.973443	9.557121	10.442879	10.026557	10.469435	10
51	9.530915	9.973398	9.557517	10.442483	10.026602	10.469085	9
52	9.531265	9.973352	9.557912	10.442088	10.026648	10.468735	8
53	9.531614	9.973307	9.558308	10.441692	10.026693	10.468386	7
54	9.531963	9.973261	9.558702	10.441298	10.026739	10.468037	6
55	9.532312	9.973215	9.559097	10.440903	10.026785	10.467688	5
56	9.532661	9.973169	9.559491	10.440509	10.026831	10.467339	4
57	9.533009	9.973124	9.559885	10.440115	10.026876	10.466991	3
58	9.533357	9.973078	9.560279	10.439721	10.026922	10.466643	2
59	9.533704	9.973032	9.560673	10.439327	10.026968	10.466296	1
60	9.534052	9.972986	9.561066	10.438934	10.027014	10.465948	0
	Sine		Tangent		Secant		Minutes

70 Degrees.

20 Degrees.

Minutes	Sine		Tang.		Secant	
0	9.534052	9.972986	9.561066	10.438934	10.027014	10.465948
1	9.534399	9.972940	9.561459	10.438541	10.027060	10.465601
2	9.534745	9.972894	9.561851	10.438149	10.027106	10.465255
3	9.535092	9.972848	9.562244	10.437756	10.027152	10.464908
4	9.535437	9.972802	9.562636	10.437364	10.027198	10.464561
5	9.535783	9.972755	9.563028	10.436972	10.027245	10.464217
6	9.536129	9.972709	9.563419	10.436581	10.027291	10.463871
7	9.536474	9.972663	9.563811	10.436189	10.027337	10.463526
8	9.536818	9.972617	9.564202	10.435798	10.027383	10.463182
9	9.537163	9.972570	9.564592	10.435408	10.027430	10.462837
10	9.537507	9.972524	9.564983	10.435017	10.027476	10.462493
11	9.537851	9.972477	9.565373	10.434627	10.027523	10.462149
12	9.538194	9.972431	9.565763	10.434237	10.027569	10.461806
13	9.538538	9.972385	9.566153	10.433847	10.027615	10.461462
14	9.538880	9.972338	9.566542	10.433458	10.027662	10.461120
15	9.539223	9.972291	9.566932	10.433068	10.027709	10.460777
16	9.539565	9.972245	9.567321	10.432679	10.027755	10.460435
17	9.539907	9.972198	9.567709	10.432291	10.027802	10.460093
18	9.540249	9.972151	9.568098	10.431902	10.027849	10.459751
19	9.540590	9.972105	9.568486	10.431514	10.027895	10.459410
20	9.540931	9.972058	9.568873	10.431127	10.027942	10.459069
21	9.541272	9.972011	9.569261	10.430739	10.027989	10.458728
22	9.541613	9.971964	9.569648	10.430352	10.028036	10.458387
23	9.541953	9.971917	9.570035	10.429965	10.028083	10.458047
24	9.542293	9.971870	9.570422	10.429578	10.028130	10.457707
25	9.542632	9.971823	9.570809	10.429191	10.028177	10.457368
26	9.542971	9.971776	9.571195	10.428805	10.028224	10.457029
27	9.543310	9.971729	9.571581	10.428419	10.028271	10.456690
28	9.543649	9.971682	9.571967	10.428033	10.028318	10.456351
29	9.543987	9.971635	9.572352	10.427648	10.028365	10.456013
30	9.544325	9.971588	9.572738	10.427262	10.028412	10.455675
	Sine		Tang.		Secant	Minutes

69 Degrees.

20 Degrees.

Minutes	Sine		Tang.		Secant		Minutes
30	9.544325	9.971588	9.572738	10.427262	10.028412	10.455675	30
31	9.544663	9.971540	9.573123	10.426877	10.028460	10.455337	29
32	9.545001	9.971493	9.573507	10.426493	10.028507	10.454999	28
33	9.545338	9.971446	9.573892	10.426108	10.028554	10.454662	27
34	9.545674	9.971398	9.574276	10.425724	10.028602	10.454326	26
35	9.546011	9.971351	9.574660	10.425340	10.028649	10.453989	25
36	9.546347	9.971303	9.575044	10.424956	10.028697	10.453653	24
37	9.546683	9.971256	9.575427	10.424573	10.028744	10.453317	23
38	9.547019	9.971208	9.575810	10.424190	10.028792	10.452981	22
39	9.547354	9.971161	9.576193	10.423807	10.028839	10.452646	21
40	9.547689	9.971113	9.576576	10.423424	10.028887	10.452311	20
41	9.548024	9.971065	9.576958	10.423042	10.028935	10.451976	19
42	9.548358	9.971018	9.577341	10.422659	10.028982	10.451642	18
43	9.548693	9.970970	9.577723	10.422277	10.029030	10.451307	17
44	9.549027	9.970922	9.578104	10.421896	10.029078	10.450973	16
45	9.549360	9.970874	9.578486	10.421514	10.029126	10.450640	15
46	9.549693	9.970826	9.578867	10.421133	10.029174	10.450307	14
47	9.550026	9.970779	9.579248	10.420752	10.029221	10.449974	13
48	9.550359	9.970731	9.579629	10.420371	10.029269	10.449641	12
49	9.550692	9.970683	9.580009	10.419991	10.029317	10.449308	11
50	9.551024	9.970635	9.580389	10.419611	10.029365	10.448976	10
51	9.551356	9.970586	9.580769	10.419231	10.029414	10.448644	9
52	9.551687	9.970538	9.581149	10.418851	10.029462	10.448313	8
53	9.552018	9.970490	9.581528	10.418472	10.029510	10.447982	7
54	9.552349	9.970442	9.581907	10.418093	10.029558	10.447651	6
55	9.552680	9.970394	9.582286	10.417714	10.029606	10.447320	5
56	9.553010	9.970345	9.582665	10.417335	10.029655	10.446990	4
57	9.553341	9.970297	9.583043	10.416957	10.029703	10.446659	3
58	9.553670	9.970248	9.583422	10.416578	10.029751	10.446330	2
59	9.554000	9.970200	9.583800	10.416200	10.029800	10.446000	1
60	9.554329	9.970152	9.584177	10.415823	10.029848	10.445671	0
	Sine		Tangent		Secant		Minutes

69 Degrees.

21 Degrees.

Minutes	Sine		Tang.		Secant	
0	9.554329	9.970152	9.584177	10.415823	10.029848	10.445671
1	9.554658	9.970103	9.584555	10.415445	10.029897	10.445342
2	9.554987	9.970055	9.584932	10.415068	10.029945	10.445013
3	9.555315	9.970006	9.585309	10.414691	10.029994	10.444685
4	9.555643	9.969957	9.585686	10.414314	10.030043	10.444357
5	9.555971	9.969909	9.586062	10.413938	10.030091	10.444029
6	9.556299	9.969860	9.586439	10.413561	10.030140	10.443701
7	9.556626	9.969811	9.586815	10.413185	10.030189	10.443374
8	9.556953	9.969762	9.587190	10.412810	10.030238	10.443047
9	9.557280	9.969714	9.587566	10.412434	10.030286	10.442720
10	9.557606	9.969665	9.587941	10.412059	10.030335	10.442394
11	9.557932	9.969616	9.588316	10.411684	10.030384	10.442068
12	9.558258	9.969567	9.588691	10.411309	10.030433	10.441742
13	9.558583	9.969518	9.589066	10.410934	10.030482	10.441417
14	9.558909	9.969469	9.589440	10.410560	10.030531	10.441091
15	9.559234	9.969420	9.589814	10.410186	10.030580	10.440766
16	9.559558	9.969370	9.590188	10.409812	10.030630	10.440442
17	9.559883	9.969321	9.590562	10.409438	10.030679	10.440117
18	9.560207	9.969272	9.590935	10.409065	10.030728	10.439793
19	9.560531	9.969223	9.591308	10.408692	10.030777	10.439469
20	9.560855	9.969173	9.591681	10.408319	10.030827	10.439145
21	9.561178	9.969124	9.592054	10.407946	10.030876	10.438822
22	9.561501	9.969075	9.592426	10.407574	10.030925	10.438499
23	9.561824	9.969025	9.592798	10.407202	10.030975	10.438176
24	9.562146	9.968976	9.593170	10.406830	10.031024	10.437854
25	9.562468	9.968926	9.593542	10.406458	10.031074	10.437532
26	9.562790	9.968877	9.593914	10.406086	10.031123	10.437210
27	9.563112	9.968827	9.594285	10.405715	10.031173	10.436888
28	9.563434	9.968777	9.594656	10.405344	10.031223	10.436566
29	9.563755	9.968728	9.595027	10.404973	10.031272	10.436245
30	9.564075	9.968678	9.595397	10.404603	10.031322	10.435925
Minutes	Sine		Tang.		Secant	Minutes

68 Degrees.

Tangents, and Secants.

(401)

21 Degrees.

Minutes	Sine		Tang.		Secant		Minutes
30	9.564075	9.968678	9.595397	10.404603	10.031322	10.435925	30
31	9.564396	9.968628	9.595768	10.404232	10.031372	10.435604	29
32	9.564716	9.968578	9.596138	10.403862	10.031422	10.435284	28
33	9.565036	9.968528	9.596508	10.403492	10.031472	10.434964	27
34	9.565356	9.968479	9.596878	10.403122	10.031521	10.434644	26
35	9.565676	9.968429	9.597247	10.402753	10.031571	10.434324	25
36	9.565995	9.968379	9.597616	10.402384	10.031621	10.434005	24
37	9.566314	9.968328	9.597985	10.402015	10.031672	10.433686	23
38	9.566632	9.968278	9.598354	10.401646	10.031722	10.433368	22
39	9.566951	9.968228	9.598722	10.401278	10.031772	10.433049	21
40	9.567269	9.968178	9.599091	10.400909	10.031822	10.432731	20
41	9.567587	9.968128	9.599459	10.400541	10.031872	10.432413	19
42	9.567904	9.968078	9.599827	10.400173	10.031922	10.432096	18
43	9.568222	9.968027	9.600194	10.399806	10.031973	10.431778	17
44	9.568539	9.967977	9.600562	10.399438	10.032023	10.431461	16
45	9.568855	9.967927	9.600929	10.399071	10.032073	10.431145	15
46	9.569172	9.967876	9.601296	10.398704	10.032124	10.430828	14
47	9.569488	9.967826	9.601662	10.398338	10.032174	10.430512	13
48	9.569804	9.967775	9.602029	10.397971	10.032225	10.430196	12
49	9.570120	9.967725	9.602395	10.397605	10.032275	10.429880	11
50	9.570435	9.967674	9.602761	10.397239	10.032326	10.429565	10
51	9.570751	9.967623	9.603127	10.396873	10.032377	10.429249	9
52	9.571066	9.967573	9.603493	10.396507	10.032427	10.428934	8
53	9.571380	9.967522	9.603858	10.396142	10.032478	10.428620	7
54	9.571695	9.967471	9.604223	10.395777	10.032529	10.428305	6
55	9.572009	9.967420	9.604588	10.395412	10.032580	10.427991	5
56	9.572323	9.967370	9.604953	10.395047	10.032630	10.427677	4
57	9.572636	9.967319	9.605317	10.394683	10.032681	10.427364	3
58	9.572949	9.967268	9.605682	10.394318	10.032732	10.427051	2
59	9.573263	9.967217	9.606046	10.393954	10.032783	10.426737	1
60	9.573575	9.967166	9.606410	10.393590	10.032834	10.426425	0
	Sine		Tang.		Secant		Minutes

68 Degrees.

22 Degrees.

Minutes	Sine		Tang.		Secant		
09	573515	9.967166	9.606410	10.393590	10.032834	10.426425	60
19	573888	9.967115	9.606773	10.393227	10.032885	10.426112	59
29	574200	9.967064	9.607137	10.392863	10.032936	10.425800	58
39	574512	9.967013	9.607500	10.392500	10.032987	10.425488	57
49	574824	9.966961	9.607863	10.392137	10.033039	10.425176	56
59	575136	9.966910	9.608225	10.391775	10.033090	10.424864	55
69	575447	9.966859	9.608588	10.391412	10.033141	10.424553	54
79	575758	9.966807	9.608950	10.391050	10.033193	10.424242	53
89	576068	9.966756	9.609312	10.390688	10.033244	10.423932	52
99	576379	9.966705	9.609674	10.390326	10.033295	10.423621	51
109	576689	9.966653	9.610036	10.389964	10.033347	10.423311	50
119	576999	9.966602	9.610397	10.389603	10.033398	10.423001	49
129	577309	9.966550	9.610759	10.389241	10.033450	10.422691	48
139	577618	9.966499	9.611120	10.388880	10.033501	10.422382	47
149	577927	9.966447	9.611480	10.388520	10.033553	10.422073	46
159	578236	9.966395	9.611841	10.388159	10.033605	10.421764	45
169	578545	9.966344	9.612201	10.387799	10.033656	10.421455	44
179	578854	9.966292	9.612561	10.387439	10.033708	10.421146	43
189	579162	9.966240	9.612921	10.387079	10.033760	10.420838	42
199	579465	9.966188	9.613281	10.386719	10.033812	10.420531	41
209	579777	9.966137	9.613641	10.386359	10.033863	10.420223	40
219	580085	9.966085	9.614000	10.386000	10.033915	10.419915	39
229	580392	9.966033	9.614359	10.385641	10.033967	10.419608	38
239	580699	9.965981	9.614718	10.385282	10.034019	10.419301	37
249	581005	9.965928	9.615077	10.384923	10.034072	10.418995	36
259	581312	9.965876	9.615435	10.384565	10.034124	10.418688	35
269	581618	9.965824	9.615793	10.384207	10.034176	10.418382	34
279	581924	9.965772	9.616151	10.383849	10.034228	10.418076	33
289	582229	9.965720	9.616509	10.383491	10.034280	10.417771	32
299	582533	9.965669	9.616867	10.383133	10.034332	10.417465	31
309	582840	9.965615	9.617224	10.382776	10.034385	10.417166	30
	Sine		Tang.		Secant		Minutes

67 Degrees.

Tangents, and Secants.

(403)

22 Degrees.

Minutes	Sine		Tang.		Secant		
30	9.582840	9.965615	9.617224	10.382771	10.034385	10.417160	30
31	9.583145	9.965563	9.617582	10.382418	10.034437	10.416855	29
32	9.583449	9.965511	9.617939	10.382061	10.034489	10.416551	28
33	9.583754	9.965458	9.618295	10.381708	10.034542	10.416246	27
34	9.584058	9.965406	9.618652	10.381348	10.034594	10.415942	26
35	9.584361	9.965353	9.619008	10.380992	10.034647	10.415639	25
36	9.584665	9.965301	9.619365	10.380635	10.034699	10.415335	24
37	9.584968	9.965248	9.619721	10.380279	10.034752	10.415032	23
38	9.585272	9.965195	9.620076	10.379924	10.034805	10.414728	22
39	9.585574	9.965143	9.620432	10.379568	10.034857	10.414426	21
40	9.585877	9.965090	9.620787	10.379213	10.034910	10.414123	20
41	9.586180	9.965037	9.621142	10.378858	10.034963	10.413820	19
42	9.586482	9.964984	9.621497	10.378503	10.035016	10.413518	18
43	9.586784	9.964931	9.621852	10.378148	10.035069	10.413216	17
44	9.587085	9.964879	9.622207	10.377793	10.035121	10.412915	16
45	9.587386	9.964826	9.622561	10.377439	10.035174	10.412614	15
46	9.587688	9.964773	9.622915	10.377085	10.035227	10.412312	14
47	9.587988	9.964719	9.623269	10.376731	10.035281	10.412012	13
48	9.588289	9.964666	9.623623	10.376377	10.035334	10.411711	12
49	9.588590	9.964613	9.623976	10.376024	10.035387	10.411410	11
50	9.588890	9.964560	9.624330	10.375670	10.035440	10.411110	10
51	9.589190	9.964507	9.624683	10.375317	10.035493	10.410810	9
52	9.589489	9.964454	9.625036	10.374964	10.035546	10.410511	8
53	9.589789	9.964400	9.625388	10.374612	10.035600	10.410211	7
54	9.590088	9.964347	9.625741	10.374259	10.035653	10.409912	6
55	9.590387	9.964294	9.626093	10.373907	10.035706	10.409613	5
56	9.590686	9.964240	9.626445	10.373555	10.035760	10.409314	4
57	9.590984	9.964187	9.626797	10.373203	10.035813	10.409016	3
58	9.591282	9.964133	9.627149	10.372851	10.035867	10.408718	2
59	9.591580	9.964080	9.627501	10.372499	10.035920	10.408420	1
60	9.591878	9.964026	9.627852	10.372247	10.035974	10.408122	0
	Sine		Tang.		Secant		Minute

67 Degrees.

23 Degrees.

Minutes	Sine		Tang.		Secant		Minutes
0	9.59187	9.964025	9.627852	10.372148	10.035974	10.408122	60
1	9.592175	9.963972	9.628203	10.371797	10.036028	10.407825	59
2	9.592473	9.963919	9.628554	10.371446	10.036081	10.407527	58
3	9.592770	9.963865	9.628905	10.371095	10.036135	10.407230	57
4	9.59306	9.963811	9.629255	10.370745	10.036189	10.406933	56
5	9.593363	9.963757	9.629606	10.370394	10.036243	10.406637	55
6	9.593659	9.963704	9.629956	10.370044	10.036296	10.406341	54
7	9.593955	9.963650	9.630306	10.369694	10.03635	10.406045	53
8	9.594251	9.963596	9.630656	10.369344	10.036404	10.405749	52
9	9.594547	9.963542	9.631005	10.368995	10.036457	10.405453	51
10	9.594842	9.963488	9.631354	10.368646	10.036512	10.405158	50
11	9.595137	9.963434	9.631704	10.368296	10.036566	10.404863	49
12	9.595432	9.963379	9.632053	10.367947	10.036621	10.404568	48
13	9.595727	9.963325	9.632401	10.367599	10.036675	10.404273	47
14	9.596021	9.963271	9.632750	10.367250	10.036729	10.403979	46
15	9.596315	9.963217	9.633098	10.366902	10.036783	10.403685	45
16	9.596609	9.963162	9.633447	10.366553	10.036838	10.403391	44
17	9.596903	9.963108	9.633795	10.366205	10.036892	10.403097	43
18	9.597196	9.963054	9.634143	10.365857	10.036946	10.402804	42
19	9.597490	9.962999	9.634490	10.365510	10.037001	10.402510	41
20	9.597783	9.962945	9.634838	10.365162	10.037055	10.402217	40
21	9.598075	9.962890	9.635185	10.364815	10.037110	10.401925	39
22	9.598368	9.962836	9.635532	10.364468	10.037164	10.401632	38
23	9.598660	9.962781	9.635879	10.364121	10.037219	10.401340	37
24	9.598952	9.962727	9.636226	10.363774	10.037273	10.401048	36
25	9.599244	9.962672	9.636572	10.363428	10.037328	10.400756	35
26	9.599536	9.962617	9.636918	10.363082	10.037383	10.400464	34
27	9.599827	9.962562	9.637265	10.362735	10.037438	10.400173	33
28	9.600118	9.962508	9.637611	10.362389	10.037492	10.399882	32
29	9.600409	9.962453	9.637956	10.362044	10.037547	10.399591	31
30	9.600700	9.962399	9.638302	10.361698	10.037602	10.399300	30
	Sine		Tang.		Secant		Minutes

66 Degrees.

23 Degrees.

Minutes	Sine	Tang.	Secant	Minutes
30	9.600700	9.638302	10.361698	30
31	9.600990	9.638647	10.361353	29
32	9.601280	9.638992	10.361003	28
33	9.601570	9.639337	10.360663	27
34	9.601860	9.639682	10.360318	26
35	9.602149	9.640027	10.359973	25
36	9.602439	9.640371	10.359629	24
37	9.602728	9.640716	10.359284	23
38	9.603017	9.641060	10.358940	22
39	9.603305	9.641404	10.358596	21
40	9.603594	9.641747	10.358253	20
41	9.603882	9.642091	10.357909	19
42	9.604170	9.642434	10.357566	18
43	9.604457	9.642777	10.357223	17
44	9.604745	9.643120	10.356880	16
45	9.605032	9.643463	10.356537	15
46	9.605319	9.643806	10.356194	14
47	9.605606	9.644148	10.355852	13
48	9.605892	9.644490	10.355510	12
49	9.606179	9.644832	10.355168	11
50	9.606465	9.645174	10.354826	10
51	9.606751	9.645516	10.354484	9
52	9.607036	9.645857	10.354143	8
53	9.607322	9.646199	10.353801	7
54	9.607607	9.646540	10.353460	6
55	9.607892	9.646881	10.353119	5
56	9.608176	9.647222	10.352778	4
57	9.608461	9.647562	10.352438	3
58	9.608745	9.647903	10.352097	2
59	9.609029	9.648243	10.351757	1
60	9.609313	9.648583	10.351417	0
	Sine	Tangent	Secant	Minutes

66 Degrees.

24 Degrees.

Minutes	Sine		Tang.		Secant		Minutes
0	9.609313	9.960730	9.648583	10.351417	10.039270	10.390687	60
1	9.609597	9.960674	9.648923	10.351077	10.039326	10.390403	59
2	9.609880	9.960618	9.649263	10.350737	10.039382	10.390120	58
3	9.610163	9.960561	9.649602	10.350398	10.039439	10.389837	57
4	9.610446	9.960505	9.649942	10.350058	10.039495	10.389554	56
5	9.610729	9.960448	9.650281	10.349719	10.039552	10.389271	55
6	9.611012	9.960392	9.650620	10.349380	10.039608	10.388988	54
7	9.611294	9.960335	9.650959	10.349041	10.039665	10.388706	53
8	9.611576	9.960279	9.651297	10.348703	10.039721	10.388424	52
9	9.611858	9.960222	9.651636	10.348364	10.039778	10.388142	51
10	9.612140	9.960166	9.651974	10.348026	10.039834	10.387860	50
11	9.612421	9.960109	9.652312	10.347688	10.039891	10.387579	49
12	9.612702	9.960052	9.652650	10.347350	10.039948	10.387298	48
13	9.612983	9.959995	9.652988	10.347012	10.040005	10.387017	47
14	9.613264	9.959938	9.653326	10.346674	10.040062	10.386736	46
15	9.613545	9.959882	9.653663	10.346337	10.040118	10.386455	45
16	9.613825	9.959825	9.654000	10.346000	10.040175	10.386175	44
17	9.614105	9.959768	9.654337	10.345663	10.040232	10.385895	43
18	9.614385	9.959711	9.654674	10.345326	10.040289	10.385615	42
19	9.614665	9.959653	9.655011	10.344989	10.040347	10.385335	41
20	9.614944	9.959596	9.655348	10.344652	10.040404	10.385056	40
21	9.615223	9.959539	9.655684	10.344316	10.040461	10.384777	39
22	9.615502	9.959482	9.656020	10.343980	10.040518	10.384498	38
23	9.615781	9.959425	9.656356	10.343644	10.040575	10.384219	37
24	9.616060	9.959368	9.656692	10.343308	10.040632	10.383940	36
25	9.616338	9.959310	9.657028	10.342972	10.040690	10.383662	35
26	9.616616	9.959253	9.657364	10.342636	10.040747	10.383384	34
27	9.616894	9.959195	9.657699	10.342301	10.040805	10.383106	33
28	9.617172	9.959138	9.658034	10.341966	10.040862	10.382828	32
29	9.617450	9.959081	9.658369	10.341631	10.040919	10.382550	31
30	9.617727	9.959023	9.658704	10.341296	10.040977	10.382273	30
	Sine		Tangent		Secant		Minutes

65 Degrees.

24 Degrees.

Minutes	Sine		Tang.		Secant		
30	9.617727	9.958023	9.658704	10.341296	10.040977	10.382273	30
31	9.618004	9.958065	9.659039	10.340961	10.041035	10.381996	29
32	9.618281	9.958108	9.659373	10.340627	10.041092	10.381719	28
33	9.618558	9.958150	9.659708	10.340292	10.041150	10.381442	27
34	9.618834	9.958192	9.660042	10.339958	10.041208	10.381166	26
35	9.619110	9.958234	9.660376	10.339624	10.041266	10.380890	25
36	9.619386	9.958277	9.660710	10.339290	10.041323	10.380614	24
37	9.619662	9.958319	9.661043	10.338957	10.041381	10.380338	23
38	9.619938	9.958361	9.661377	10.338623	10.041439	10.380062	22
39	9.620213	9.958403	9.661710	10.338290	10.041497	10.379787	21
40	9.620488	9.958445	9.662043	10.337957	10.041555	10.379512	20
41	9.620763	9.958487	9.662376	10.337624	10.041613	10.379237	19
42	9.621038	9.958529	9.662709	10.337291	10.041671	10.378962	18
43	9.621313	9.958571	9.663042	10.336958	10.041729	10.378687	17
44	9.621587	9.958612	9.663375	10.336625	10.041788	10.378413	16
45	9.621861	9.958654	9.663707	10.336293	10.041846	10.378139	15
46	9.622135	9.958696	9.664039	10.335961	10.041904	10.377865	14
47	9.622409	9.958738	9.664371	10.335629	10.041962	10.377591	13
48	9.622682	9.958779	9.664703	10.335297	10.042021	10.377318	12
49	9.622956	9.958821	9.665035	10.334965	10.042079	10.377044	11
50	9.623229	9.958863	9.665366	10.334634	10.042137	10.376771	10
51	9.623502	9.958904	9.665697	10.334303	10.042196	10.376498	9
52	9.623774	9.958946	9.666029	10.333971	10.042254	10.376226	8
53	9.624047	9.958987	9.666360	10.333640	10.042313	10.375953	7
54	9.624319	9.959028	9.666691	10.333309	10.042372	10.375681	6
55	9.624591	9.959070	9.667021	10.332979	10.042430	10.375409	5
56	9.624863	9.959111	9.667352	10.332648	10.042489	10.375137	4
57	9.625135	9.959152	9.667682	10.332318	10.042548	10.374865	3
58	9.625406	9.959193	9.668013	10.331987	10.042607	10.374594	2
59	9.625677	9.959235	9.668343	10.331657	10.042665	10.374323	1
60	9.625948	9.959276	9.668672	10.331328	10.042724	10.374052	C
	Sine		Tangent		Secant		Minutes

65 Degrees.

(408) A Table of Artificial Sines,

25 Degrees.

Minutes	Sine		Tang.		Secant		Minutes
0	9.625948	9.957276	9.668072	10.331328	10.042724	10.374052	60
1	9.626219	9.957217	9.669002	10.330991	10.042783	10.373781	59
2	9.626490	9.957158	9.669332	10.330661	10.042842	10.373510	58
3	9.626760	9.957099	9.669661	10.330331	10.042901	10.373240	57
4	9.627030	9.957040	9.669991	10.330001	10.042960	10.372970	56
5	9.627300	9.956981	9.670320	10.329680	10.043019	10.372700	55
6	9.627570	9.956922	9.670649	10.329351	10.043078	10.372430	54
7	9.627840	9.956862	9.670977	10.329023	10.043138	10.372160	53
8	9.628109	9.956803	9.671306	10.328694	10.043197	10.372891	52
9	9.628378	9.956744	9.671634	10.328366	10.043256	10.371622	51
10	9.628647	9.956684	9.671963	10.328037	10.043316	10.371353	50
11	9.628916	9.956625	9.672291	10.327709	10.043375	10.371084	49
12	9.629184	9.956566	9.672619	10.327381	10.043434	10.370816	48
13	9.629453	9.956506	9.672947	10.327053	10.043494	10.370547	47
14	9.629721	9.956447	9.673274	10.326726	10.043553	10.370279	46
15	9.629989	9.956387	9.673602	10.326398	10.043613	10.370011	45
16	9.630257	9.956327	9.673929	10.326071	10.043673	10.369743	44
17	9.630524	9.956268	9.674257	10.325743	10.043732	10.369476	43
18	9.630792	9.956208	9.674584	10.325416	10.043792	10.369208	42
19	9.631059	9.956148	9.674910	10.325090	10.043852	10.368941	41
20	9.631326	9.956089	9.675237	10.324763	10.043911	10.368674	40
21	9.631593	9.956029	9.675564	10.324436	10.043971	10.368407	39
22	9.631859	9.955969	9.675890	10.324110	10.044031	10.368141	38
23	9.632126	9.955909	9.676216	10.323784	10.044091	10.367874	37
24	9.632392	9.955849	9.676543	10.323457	10.044151	10.367608	36
25	9.632658	9.955789	9.676869	10.323131	10.044211	10.367342	35
26	9.632923	9.955729	9.677194	10.322806	10.044271	10.367077	34
27	9.633189	9.955669	9.677520	10.322480	10.044331	10.366811	33
28	9.633454	9.955609	9.677846	10.322155	10.044391	10.366546	32
29	9.633719	9.955548	9.678171	10.321829	10.044452	10.366281	31
30	9.633984	9.955488	9.678496	10.321504	10.044512	10.366016	30
	Sine		Tangent		Secant		Minutes

64 Degrees.

Tangents, and Secants.

(409)

25 Degrees.

Minutes	Sine		Tang.		Secant		Minutes
30	9.633984	9.955488	9.678496	10.321504	10.044512	10.366016	30
31	9.634249	9.955428	9.678821	10.321179	10.044572	10.365751	29
32	9.634514	9.955368	9.679146	10.320854	10.044632	10.365486	28
33	9.634778	9.955307	9.679471	10.320529	10.044693	10.365222	27
34	9.635042	9.955247	9.679795	10.320205	10.044753	10.364958	26
35	9.635306	9.955186	9.680120	10.319880	10.044814	10.364694	25
36	9.635570	9.955126	9.680444	10.319556	10.044874	10.364430	24
37	9.635833	9.955065	9.680768	10.319232	10.044935	10.364167	23
38	9.636097	9.955005	9.681092	10.318908	10.044995	10.363903	22
39	9.636360	9.954944	9.681416	10.318584	10.045056	10.363640	21
40	9.636623	9.954883	9.681740	10.318260	10.045117	10.363377	20
41	9.636886	9.954823	9.682063	10.317937	10.045177	10.363114	19
42	9.637148	9.954762	9.682386	10.317614	10.045238	10.362852	18
43	9.637411	9.954701	9.682710	10.317290	10.045299	10.362589	17
44	9.637673	9.954640	9.683033	10.316967	10.045360	10.362327	16
45	9.637935	9.954579	9.683356	10.316644	10.045421	10.362065	15
46	9.638197	9.954518	9.683678	10.316322	10.045482	10.361803	14
47	9.638458	9.954457	9.684001	10.315999	10.045543	10.361542	13
48	9.638720	9.954396	9.684324	10.315676	10.045604	10.361280	12
49	9.638981	9.954335	9.684646	10.315354	10.045665	10.361019	11
50	9.639242	9.954274	9.684968	10.315032	10.045726	10.360758	10
51	9.639503	9.954213	9.685290	10.314710	10.045787	10.360497	9
52	9.639764	9.954152	9.685612	10.314388	10.045848	10.360236	8
53	9.640024	9.954090	9.685934	10.314066	10.045910	10.359976	7
54	9.640284	9.954029	9.686255	10.313745	10.045971	10.359716	6
55	9.640544	9.953968	9.686577	10.313423	10.046032	10.359456	5
56	9.640804	9.953906	9.686898	10.313102	10.046094	10.359196	4
57	9.641064	9.953845	9.687219	10.312781	10.046155	10.358936	3
58	9.641323	9.953783	9.687540	10.312460	10.046217	10.358677	2
59	9.641583	9.953722	9.687861	10.312139	10.046278	10.358417	1
60	9.641842	9.953660	9.688182	10.311818	10.046340	10.358158	0
	Sine		Tangent		Secant		Minutes

64 Degrees.

26 Degrees.

Minutes	Sine		Tang.		Secant	
0	9.641842	9.953060	9.588182	10.311818	10.046340	10.358158
1	9.642101	9.953598	9.688502	10.311498	10.046402	10.357899
2	9.642360	9.953537	9.688823	10.311177	10.046463	10.357640
3	9.642618	9.953475	9.689143	10.310857	10.046525	10.357382
4	9.642876	9.953413	9.689463	10.310537	10.046587	10.357124
5	9.643135	9.953352	9.689783	10.310217	10.046648	10.356865
6	9.643393	9.953290	9.690103	10.309897	10.046710	10.356607
7	9.643650	9.953228	9.690423	10.309577	10.046772	10.356350
8	9.643908	9.953166	9.690742	10.309258	10.046834	10.356092
9	9.644166	9.953104	9.691062	10.308938	10.046896	10.355835
10	9.644423	9.953042	9.691381	10.308619	10.046958	10.355577
11	9.644680	9.952980	9.691700	10.308300	10.047020	10.355320
12	9.644937	9.952917	9.692019	10.307981	10.047083	10.355063
13	9.645193	9.952855	9.692338	10.307662	10.047145	10.354807
14	9.645450	9.952793	9.692657	10.307343	10.047207	10.354550
15	9.645706	9.952731	9.692975	10.307025	10.047269	10.354294
16	9.645962	9.952669	9.693293	10.306707	10.047331	10.354038
17	9.646218	9.952606	9.693612	10.306388	10.047394	10.353782
18	9.646474	9.952544	9.693930	10.306070	10.047456	10.353526
19	9.646729	9.952481	9.694248	10.305752	10.047519	10.353271
20	9.646984	9.952419	9.694566	10.305434	10.047581	10.353016
21	9.647239	9.952356	9.694883	10.305117	10.047644	10.352761
22	9.647495	9.952294	9.695201	10.304799	10.047706	10.352505
23	9.647749	9.952231	9.695518	10.304482	10.047769	10.352251
24	9.648004	9.952168	9.695836	10.304164	10.047832	10.351996
25	9.648258	9.952105	9.696153	10.303847	10.047895	10.351742
26	9.648512	9.952043	9.696470	10.303530	10.047957	10.351488
27	9.648766	9.951980	9.696787	10.303213	10.048020	10.351234
28	9.649020	9.951917	9.697103	10.302897	10.048083	10.350980
29	9.649274	9.951854	9.697420	10.302580	10.048146	10.350726
30	9.649527	9.951791	9.697736	10.302264	10.048209	10.350473
		Sine		Tangent		Secant

63 Degrees.

Tangents, and Secants.

(411)

26 Degrees.

Minutes	Sine		Tang.		Secant		Minutes
30	9.649527	9.951791	9.697736	10.302264	10.048209	10.350473	30
31	9.649781	9.951728	9.698053	10.301947	10.048272	10.350219	29
32	9.650034	9.951665	9.698369	10.301631	10.048335	10.349966	28
33	9.650287	9.951602	9.698685	10.301315	10.048398	10.349713	27
34	9.650539	9.951539	9.699001	10.300999	10.048461	10.349461	26
35	9.650792	9.951476	9.699316	10.300684	10.048524	10.349208	25
36	9.651044	9.951412	9.699632	10.300368	10.048588	10.348956	24
37	9.651297	9.951349	9.699947	10.300053	10.048651	10.348703	23
38	9.651549	9.951286	9.700263	10.299737	10.048714	10.348451	22
39	9.651800	9.951222	9.700578	10.299422	10.048776	10.348200	21
40	9.652052	9.951159	9.700893	10.299107	10.048841	10.347948	20
41	9.652304	9.951096	9.701208	10.298792	10.048904	10.347696	19
42	9.652555	9.951032	9.701523	10.298477	10.048968	10.347445	18
43	9.652806	9.950968	9.701837	10.298163	10.049032	10.347194	17
44	9.653057	9.950905	9.702152	10.297848	10.049095	10.346943	16
45	9.653307	9.950841	9.702466	10.297534	10.049159	10.346693	15
46	9.653558	9.950778	9.702780	10.297220	10.049222	10.346442	14
47	9.653808	9.950714	9.703095	10.296905	10.049286	10.346192	13
48	9.654059	9.950650	9.703409	10.296591	10.049350	10.345941	12
49	9.654309	9.950586	9.703723	10.296277	10.049414	10.345691	11
50	9.654558	9.950522	9.704036	10.295964	10.049478	10.345442	10
51	9.654808	9.950458	9.704350	10.295650	10.049542	10.345192	9
52	9.655057	9.950394	9.704663	10.295337	10.049606	10.344943	8
53	9.655307	9.950330	9.704977	10.295023	10.049670	10.344693	7
54	9.655556	9.950266	9.705290	10.294710	10.049734	10.344444	6
55	9.655805	9.950202	9.705603	10.294397	10.049798	10.344195	5
56	9.656054	9.950138	9.705916	10.294084	10.049862	10.343946	4
57	9.656302	9.950074	9.706228	10.293772	10.049926	10.343698	3
58	9.656551	9.950009	9.706541	10.293459	10.049991	10.343449	2
59	9.656799	9.949945	9.706854	10.293146	10.050055	10.343201	1
60	9.657047	9.949881	9.707166	10.292834	10.050119	10.342953	0
	Sine		Tangent		Secant		Minutes

63 Degrees.

27 Degrees.

Minutes	Sine	Tang.	Secant	
0	9.657047	9.949831	9.707106	10.292334
1	9.657295	9.949816	9.707478	10.292522
2	9.657542	9.949752	9.707790	10.292210
3	9.657790	9.949688	9.708102	10.291898
4	9.658037	9.949623	9.708414	10.291586
5	9.658284	9.949558	9.708720	10.291274
6	9.658531	9.949494	9.709037	10.290963
7	9.658778	9.949429	9.709349	10.290651
8	9.659025	9.949364	9.709660	10.290340
9	9.659271	9.949300	9.709971	10.290029
10	9.659517	9.949235	9.710282	10.289718
11	9.659763	9.949170	9.710593	10.289407
12	9.660009	9.949105	9.710904	10.289096
13	9.660255	9.949040	9.711215	10.288785
14	9.660500	9.948975	9.711525	10.288475
15	9.660746	9.948910	9.711836	10.288164
16	9.660991	9.948845	9.712146	10.287854
17	9.661236	9.948780	9.712456	10.287544
18	9.661481	9.948715	9.712766	10.287234
19	9.661726	9.948649	9.713076	10.286924
20	9.661970	9.948584	9.713386	10.286614
21	9.662214	9.948519	9.713596	10.286304
22	9.662459	9.948453	9.714005	10.285995
23	9.662703	9.948388	9.714314	10.285686
24	9.662946	9.948323	9.714624	10.285376
25	9.663190	9.948257	9.714933	10.285067
26	9.663433	9.948192	9.715242	10.284758
27	9.663677	9.948126	9.715551	10.284449
28	9.663920	9.948060	9.715859	10.284141
29	9.664163	9.947995	9.716168	10.283832
30	9.664406	9.947929	9.716477	10.283523
	Sine		Tangent	Secant
				Minutes

62 Degrees.

Tangents, and Secants.

(413)

27 Degrees.

Minutes	Sine		Tang.		Secant		
30	9.664406	9.947929	9.716477	10.283523	10.052071	10.335594	30
31	9.664648	9.947863	9.716785	10.283215	10.052137	10.335352	29
32	9.664891	9.947797	9.717093	10.282907	10.052203	10.335109	28
33	9.665133	9.947731	9.717401	10.282599	10.052269	10.334867	27
34	9.665375	9.947665	9.717709	10.282291	10.052335	10.334625	26
35	9.665617	9.947599	9.718017	10.282983	10.052401	10.334383	25
36	9.665859	9.947533	9.718325	10.281675	10.052467	10.334141	24
37	9.666100	9.947467	9.718633	10.281367	10.052533	10.333900	23
38	9.666341	9.947401	9.718940	10.281060	10.052599	10.333659	22
39	9.666583	9.947335	9.719248	10.280752	10.052665	10.333417	21
40	9.666824	9.947269	9.719555	10.280445	10.052731	10.333176	20
41	9.667065	9.947203	9.719862	10.280138	10.052797	10.332935	19
42	9.667305	9.947136	9.720169	10.279831	10.052864	10.332695	18
43	9.667546	9.947070	9.720476	10.279524	10.052930	10.332454	17
44	9.667786	9.947004	9.720783	10.279217	10.052996	10.332214	16
45	9.668026	9.946937	9.721089	10.278911	10.053063	10.331974	15
46	9.668266	9.946871	9.721396	10.278604	10.053129	10.331734	14
47	9.668506	9.946804	9.721702	10.278298	10.053196	10.331494	13
48	9.668746	9.946738	9.722008	10.277992	10.053262	10.331254	12
49	9.668986	9.946671	9.722315	10.277685	10.053329	10.331014	11
50	9.669225	9.946604	9.722621	10.277379	10.053396	10.330775	10
51	9.669464	9.946538	9.722927	10.277073	10.053462	10.330536	9
52	9.669703	9.946471	9.723232	10.276768	10.053529	10.330297	8
53	9.669942	9.946404	9.723538	10.276462	10.053596	10.330058	7
54	9.670181	9.946337	9.723844	10.276156	10.053663	10.329819	6
55	9.670419	9.946270	9.724149	10.275851	10.053730	10.329581	5
56	9.670658	9.946203	9.724454	10.275546	10.053797	10.329342	4
57	9.670896	9.946136	9.724759	10.275241	10.053864	10.329104	3
58	9.671134	9.946069	9.725065	10.274935	10.053931	10.328866	2
59	9.671372	9.946002	9.725369	10.274631	10.053998	10.328628	1
60	9.671609	9.945935	9.725674	10.274326	10.054065	10.328391	C
	Sine		Tangent		Secant		Minutes

62 Degrees.

28 Degrees.

Minutes	Sine		Tang.	<i>Block</i>	Secant	
0	9.671609	9.945935	9.725674	10.274326	10.054065	10.328391
1	9.671847	9.945868	9.725979	10.274021	10.054132	10.328153
2	9.672084	9.945801	9.726284	10.273716	10.054199	10.327916
3	9.672321	9.945733	9.726588	10.273412	10.054267	10.327679
4	9.672558	9.945666	9.726893	10.273107	10.054334	10.327442
5	9.672795	9.945598	9.727197	10.272803	10.054402	10.327205
6	9.673032	9.945531	9.727501	10.272499	10.054469	10.326968
7	9.673268	9.945464	9.727805	10.272195	10.054536	10.326732
8	9.673505	9.945396	9.728109	10.271891	10.054604	10.326495
9	9.673741	9.945328	9.728412	10.271588	10.054672	10.326259
10	9.673977	9.945261	9.728716	10.271284	10.054739	10.326023
11	9.674213	9.945193	9.729020	10.270980	10.054807	10.325787
12	9.674448	9.945126	9.729323	10.270677	10.054874	10.325552
13	9.674684	9.945058	9.729626	10.270374	10.054942	10.325316
14	9.674919	9.944990	9.729929	10.270071	10.055010	10.325081
15	9.675155	9.944922	9.730233	10.269767	10.055078	10.324845
16	9.675390	9.944854	9.730535	10.269465	10.055146	10.324610
17	9.675625	9.944786	9.730838	10.269162	10.055214	10.324375
18	9.675859	9.944718	9.731141	10.268859	10.055282	10.324141
19	9.676094	9.944650	9.731444	10.268556	10.055350	10.323906
20	9.676328	9.944582	9.731746	10.268254	10.055418	10.323672
21	9.676562	9.944514	9.732048	10.267952	10.055486	10.323438
22	9.676796	9.944446	9.732351	10.267649	10.055554	10.323204
23	9.677030	9.944377	9.732653	10.267347	10.055623	10.322970
24	9.677264	9.944309	9.732955	10.267045	10.055691	10.322736
25	9.677498	9.944241	9.733257	10.266743	10.055759	10.322502
26	9.677731	9.944173	9.733558	10.266442	10.055827	10.322269
27	9.677964	9.944104	9.733860	10.266140	10.055896	10.322036
28	9.678197	9.944036	9.734162	10.265848	10.055964	10.321803
29	9.678430	9.943967	9.734463	10.265557	10.056033	10.321570
30	9.678663	9.943898	9.734764	10.265266	10.056102	10.321337
		Sine		Tang.		Secant

61 Degrees.

Tangents, and Secants.

(415)

28 Degrees.

Minutes	Sine	Tang.	Secant	
30	9.678663	9.943898	9.734764	10.265236
31	9.678895	9.943830	9.735066	10.264934
32	9.679128	9.943761	9.735367	10.264633
33	9.679360	9.943693	9.735668	10.264332
34	9.679592	9.943624	9.735968	10.264032
35	9.679824	9.943555	9.736269	10.263731
36	9.680056	9.943486	9.736570	10.263430
37	9.680288	9.943417	9.736871	10.263129
38	9.680519	9.943348	9.737171	10.262829
39	9.680750	9.943279	9.737471	10.262529
40	9.680982	9.943210	9.737771	10.262229
41	9.681213	9.943141	9.738071	10.261929
42	9.681443	9.943072	9.738371	10.261629
43	9.681674	9.943003	9.738671	10.261329
44	9.681905	9.942934	9.738971	10.261029
45	9.682135	9.942864	9.739271	10.260729
46	9.682365	9.942795	9.739570	10.260430
47	9.682595	9.942725	9.739870	10.260130
48	9.682825	9.942656	9.740169	10.259831
49	9.683055	9.942587	9.740468	10.259532
50	9.683284	9.942517	9.740767	10.259233
51	9.683514	9.942448	9.741066	10.258934
52	9.683743	9.942378	9.741365	10.258635
53	9.683972	9.942308	9.741664	10.258336
54	9.684201	9.942239	9.741962	10.258038
55	9.684430	9.942169	9.742261	10.257739
56	9.684658	9.942099	9.742559	10.257441
57	9.684887	9.942029	9.742858	10.257142
58	9.685115	9.941959	9.743156	10.256844
59	9.685343	9.941889	9.743454	10.256546
60	9.685571	9.941819	9.743752	10.256248
	Sine	Tangent	Secant	Minutes

61 Degrees.

29 Degrees.

Minutes	Sine	Tang.	Secant	Minutes			
0	9.685571	9.941819	9.743752	10.250248	10.058181	10.314429	60
1	9.685799	9.941749	9.744050	10.255950	10.058251	10.314201	59
2	9.686027	9.941679	9.744348	10.255652	10.058321	10.313973	58
3	9.686254	9.941609	9.744645	10.255355	10.058391	10.313746	57
4	9.686482	9.941539	9.744943	10.255057	10.058461	10.313518	56
5	9.686709	9.941468	9.745240	10.254760	10.058532	10.313291	55
6	9.686936	9.941398	9.745538	10.254462	10.058602	10.313064	54
7	9.687163	9.941328	9.745835	10.254165	10.058672	10.312837	53
8	9.687389	9.941258	9.746132	10.253868	10.058742	10.312611	52
9	9.687616	9.941187	9.746429	10.253571	10.058813	10.312384	51
10	9.687843	9.941117	9.746726	10.253274	10.058883	10.312157	50
11	9.688069	9.941046	9.747023	10.252977	10.058954	10.311931	49
12	9.688295	9.940975	9.747319	10.252681	10.059025	10.311705	48
13	9.688521	9.940905	9.747616	10.252384	10.059095	10.311479	47
14	9.688747	9.940834	9.747912	10.252088	10.059166	10.311253	46
15	9.688972	9.940763	9.748209	10.251791	10.059237	10.311028	45
16	9.689198	9.940693	9.748505	10.251495	10.059307	10.310802	44
17	9.689423	9.940622	9.748801	10.251199	10.059378	10.310577	43
18	9.689648	9.940551	9.749097	10.250903	10.059449	10.310352	42
19	9.689873	9.940480	9.749393	10.250607	10.059520	10.310127	41
20	9.690098	9.940409	9.749689	10.250311	10.059591	10.309902	40
21	9.690323	9.940338	9.749985	10.250015	10.059662	10.309677	39
22	9.690548	9.940267	9.750281	10.249719	10.059733	10.309452	38
23	9.690772	9.940196	9.750576	10.249424	10.059804	10.309228	37
24	9.690996	9.940125	9.750872	10.249128	10.059875	10.309004	36
25	9.691220	9.940053	9.751167	10.248833	10.059947	10.308780	35
26	9.691444	9.939982	9.751462	10.248538	10.060018	10.308556	34
27	9.691668	9.939911	9.751757	10.248243	10.060089	10.308332	33
28	9.691892	9.939840	9.752052	10.247948	10.060160	10.308108	32
29	9.692115	9.939768	9.752347	10.247653	10.060232	10.307885	31
30	9.692339	9.939697	9.752642	10.247358	10.060303	10.307661	30
	Sine		Tang.		Secant		Minutes

60 Degrees.

Tangents, and Secants.

(417)

29 Degrees.

Minutes	Sine		Tang.		Secant		
30	9.692339	9.939697	9.752642	10.247358	10.060303	10.307661	30
31	9.692562	9.939625	9.752937	10.247063	10.060375	10.307438	29
32	9.692785	9.939554	9.753231	10.246769	10.060446	10.307215	28
33	9.693009	9.939482	9.753526	10.246474	10.060518	10.306991	27
34	9.693231	9.939410	9.753820	10.246180	10.060590	10.306769	26
35	9.693453	9.939339	9.754115	10.245885	10.060661	10.306547	25
36	9.693676	9.939267	9.754409	10.245591	10.060733	10.306324	24
37	9.693898	9.939195	9.754703	10.245297	10.060805	10.306102	23
38	9.694120	9.939123	9.754997	10.245003	10.060877	10.305880	22
39	9.694342	9.939051	9.755291	10.244709	10.060949	10.305658	21
40	9.694564	9.938980	9.755585	10.244415	10.061020	10.305436	20
41	9.694786	9.938908	9.755878	10.244122	10.061092	10.305214	19
42	9.695007	9.938836	9.756172	10.243828	10.061164	10.304993	18
43	9.695229	9.938763	9.756465	10.243535	10.061237	10.304771	17
44	9.695450	9.938691	9.756759	10.243241	10.061309	10.304550	16
45	9.695671	9.938619	9.757052	10.242948	10.061381	10.304329	15
46	9.695892	9.938547	9.757345	10.242655	10.061453	10.304108	14
47	9.696113	9.938475	9.757638	10.242362	10.061525	10.303887	13
48	9.696334	9.938402	9.757931	10.242069	10.061598	10.303666	12
49	9.696554	9.938330	9.758224	10.241776	10.061670	10.303446	11
50	9.696774	9.938258	9.758517	10.241483	10.061742	10.303226	10
51	9.696995	9.938185	9.758810	10.241190	10.061815	10.303005	9
52	9.697215	9.938113	9.759102	10.240898	10.061887	10.302785	8
53	9.697435	9.938040	9.759395	10.240605	10.061960	10.302565	7
54	9.697654	9.937967	9.759687	10.240313	10.062033	10.302346	6
55	9.697874	9.937895	9.759979	10.240021	10.062105	10.302126	5
56	9.698094	9.937822	9.760272	10.239728	10.062178	10.301906	4
57	9.698313	9.937749	9.760564	10.239436	10.062251	10.301687	3
58	9.698532	9.937676	9.760856	10.239144	10.062324	10.301468	2
59	9.698751	9.937603	9.761148	10.238852	10.062397	10.301249	1
60	9.698970	9.937531	9.761439	10.238561	10.062469	10.301030	0
	Sine		Tang.		Secant		Minutes

60 Degrees.

D d

30 Degrees.

Minutes	Sine		Tang.		Secant		Minutes
0	9.638970	9.937531	9.761439	10.238561	10.062469	10.301030	60
1	9.699189	9.937458	9.761731	10.238269	10.062541	10.300811	59
2	9.699407	9.937385	9.762023	10.237977	10.062615	10.300593	58
3	9.699626	9.937312	9.762314	10.237686	10.062688	10.300374	57
4	9.699844	9.937238	9.762606	10.237394	10.062762	10.300156	56
5	9.700062	9.937165	9.762897	10.237103	10.062835	10.299938	55
6	9.700280	9.937092	9.763188	10.236812	10.062908	10.299720	54
7	9.700498	9.937019	9.763479	10.236521	10.062981	10.299502	53
8	9.700716	9.936946	9.763770	10.236230	10.063054	10.299284	52
9	9.700933	9.936872	9.764061	10.235939	10.063128	10.299067	51
10	9.701151	9.936799	9.764352	10.235648	10.063201	10.298849	50
11	9.701368	9.936725	9.764643	10.235357	10.063275	10.298632	49
12	9.701585	9.936652	9.764933	10.235067	10.063348	10.298415	48
13	9.701802	9.936578	9.765224	10.234776	10.063422	10.298198	47
14	9.702019	9.936505	9.765514	10.234486	10.063495	10.297981	46
15	9.702236	9.936431	9.765805	10.234195	10.063569	10.297764	45
16	9.702452	9.936357	9.766095	10.233905	10.063643	10.297548	44
17	9.702669	9.936284	9.766385	10.233615	10.063716	10.297331	43
18	9.702885	9.936210	9.766675	10.233325	10.063790	10.297115	42
19	9.703101	9.936136	9.766965	10.233035	10.063864	10.296899	41
20	9.703317	9.936062	9.767255	10.232745	10.063938	10.296683	40
21	9.703533	9.935988	9.767545	10.232455	10.064012	10.296467	39
22	9.703749	9.935914	9.767834	10.232166	10.064086	10.296251	38
23	9.703964	9.935840	9.768124	10.231876	10.064160	10.296036	37
24	9.704179	9.935766	9.768413	10.231587	10.064234	10.295821	36
25	9.704395	9.935692	9.768703	10.231297	10.064308	10.295605	35
26	9.704610	9.935618	9.768992	10.231008	10.064382	10.295390	34
27	9.704825	9.935543	9.769281	10.230719	10.064457	10.295175	33
28	9.705040	9.935469	9.769570	10.230430	10.064531	10.294960	32
29	9.705254	9.935395	9.769860	10.230140	10.064605	10.294746	31
30	9.705468	9.935320	9.770148	10.229852	10.064680	10.294531	30
	Sine		Tang.		Secant		Minutes

59 Degrees.

30 Degrees.

Minutes	Sine		Tang.		Secant		
30	9.705469	9.935320	9.770148	10.229852	10.064680	10.294531	30
31	9.705683	9.935246	9.770437	10.229563	10.064754	10.294317	29
32	9.705897	9.935171	9.770726	10.229274	10.064829	10.294103	28
33	9.706112	9.935097	9.771015	10.228985	10.064903	10.293888	27
34	9.706326	9.935022	9.771303	10.228697	10.064978	10.293674	26
35	9.706539	9.934948	9.771592	10.228408	10.065052	10.293461	25
36	9.706753	9.934873	9.771880	10.228120	10.065127	10.293247	24
37	9.706967	9.934798	9.772168	10.227832	10.065202	10.293033	23
38	9.707180	9.934723	9.772457	10.227543	10.065277	10.292820	22
39	9.707393	9.934649	9.772745	10.227255	10.065351	10.292607	21
40	9.707606	9.934574	9.773033	10.226967	10.065426	10.292394	20
41	9.707819	9.934499	9.773321	10.226679	10.065501	10.292181	19
42	9.708032	9.934424	9.773608	10.226392	10.065576	10.291968	18
43	9.708245	9.934349	9.773896	10.226104	10.065651	10.291755	17
44	9.708457	9.934274	9.774184	10.225816	10.065726	10.291543	16
45	9.708670	9.934199	9.774471	10.225529	10.065801	10.291330	15
46	9.708882	9.934123	9.774759	10.225241	10.065877	10.291118	14
47	9.709094	9.934048	9.775046	10.224954	10.065952	10.290906	13
48	9.709306	9.933973	9.775333	10.224667	10.066027	10.290694	12
49	9.709518	9.933898	9.775621	10.224379	10.066102	10.290482	11
50	9.709730	9.933822	9.775908	10.224092	10.066178	10.290270	10
51	9.709941	9.933747	9.776195	10.223805	10.066253	10.290059	9
52	9.710153	9.933671	9.776482	10.223518	10.066329	10.289847	8
53	9.710364	9.933596	9.776769	10.223231	10.066404	10.289636	7
54	9.710575	9.933520	9.777055	10.222945	10.066480	10.289425	6
55	9.710786	9.933444	9.777342	10.222658	10.066556	10.289214	5
56	9.710997	9.933369	9.777628	10.222372	10.066631	10.289003	4
57	9.711208	9.933293	9.777915	10.222085	10.066707	10.288792	3
58	9.711419	9.933217	9.778201	10.221799	10.066783	10.288581	2
59	9.711629	9.933141	9.778487	10.221513	10.066859	10.288371	1
60	9.711839	9.933066	9.778774	10.221226	10.066934	10.288161	0
	Sine		Tang.		Secant		Minutes

59 Degrees.

31 Degrees.

Minutes	Sine		Tang.		Secant		Minutes
0	9.711839	1.933066	9.778774	10.221226	10.067934	10.288161	60
1	9.712045	1.932990	9.779060	10.220940	10.067010	10.287951	59
2	9.712259	1.932914	9.779346	10.220654	10.067086	10.287741	58
3	9.712469	1.932838	9.779632	10.220368	10.067162	10.287531	57
4	9.712679	1.932762	9.779918	10.220082	10.067238	10.287321	56
5	9.712889	1.932685	9.780203	10.219797	10.067315	10.287111	55
6	9.713098	1.932609	9.780489	10.219511	10.067391	10.286902	54
7	9.713308	1.932533	9.780775	10.219225	10.067467	10.286692	53
8	9.713517	1.932457	9.781060	10.218940	10.067543	10.286483	52
9	9.713726	1.932380	9.781346	10.218654	10.067620	10.286274	51
10	9.713935	1.932304	9.781631	10.218369	10.067696	10.286065	50
11	9.714144	1.932228	9.781916	10.218084	10.067772	10.285856	49
12	9.714352	1.932151	9.782201	10.217799	10.067849	10.285648	48
13	9.714561	1.932075	9.782486	10.217514	10.067925	10.285439	47
14	9.714769	1.931998	9.782771	10.217229	10.068002	10.285231	46
15	9.714978	1.931921	9.783056	10.216944	10.068079	10.285022	45
16	9.715186	1.931845	9.783341	10.216659	10.068155	10.284814	44
17	9.715394	1.931768	9.783626	10.216374	10.068232	10.284606	43
18	9.715601	1.931691	9.783910	10.216090	10.068309	10.284399	42
19	9.715809	1.931614	9.784195	10.215805	10.068386	10.284191	41
20	9.716017	1.931537	9.784479	10.215521	10.068463	10.283983	40
21	9.716224	1.931460	9.784764	10.215236	10.068540	10.283776	39
22	9.716432	1.931383	9.785048	10.214952	10.068617	10.283568	38
23	9.716639	1.931306	9.785332	10.214668	10.068694	10.283361	37
24	9.716846	1.931229	9.785616	10.214384	10.068771	10.283154	36
25	9.717053	1.931152	9.785900	10.214100	10.068848	10.282947	35
26	9.717259	1.931075	9.786184	10.213816	10.068925	10.282741	34
27	9.717466	1.930998	9.786468	10.213532	10.069002	10.282534	33
28	9.717672	1.930920	9.786752	10.213248	10.069080	10.282328	32
29	9.717879	1.930843	9.787036	10.212964	10.069157	10.282121	31
30	9.718085	1.930766	9.787319	10.212681	10.069234	10.281915	30
	Sine		Tang.		Secant		Minutes

58 Degrees.

Tangents, and Secants.

(421)

31 Degrees.

Minutes	Sine		Tang.		Secant		
30	9.718085	9.930766	9.787319	10.212681	10.063234	10.281915	30
31	9.718291	9.930688	9.787603	10.212397	10.069312	10.281709	29
32	9.718497	9.930611	9.787886	10.212114	10.069389	10.281503	28
33	9.718703	9.930533	9.788170	10.211830	10.069467	10.281297	27
34	9.718909	9.930456	9.788453	10.211547	10.069544	10.281091	26
35	9.719114	9.930378	9.788736	10.211264	10.069622	10.280886	25
36	9.719320	9.930300	9.789019	10.210981	10.069700	10.280680	24
37	9.719525	9.930223	9.789302	10.210698	10.069777	10.280475	23
38	9.719730	9.930145	9.789585	10.210415	10.069855	10.280270	22
39	9.719935	9.930067	9.789868	10.210132	10.069933	10.280065	21
40	9.720140	9.929989	9.790151	10.209849	10.070011	10.279860	20
41	9.720345	9.929911	9.790433	10.209567	10.070089	10.279655	19
42	9.720549	9.929833	9.790716	10.209284	10.070167	10.279451	18
43	9.720754	9.929755	9.790999	10.209001	10.070245	10.279246	17
44	9.720958	9.929677	9.791281	10.208719	10.070323	10.279042	16
45	9.721162	9.929599	9.791563	10.208437	10.070401	10.278838	15
46	9.721366	9.929521	9.791846	10.208154	10.070479	10.278634	14
47	9.721570	9.929442	9.792128	10.207872	10.070558	10.278430	13
48	9.721774	9.929364	9.792410	10.207590	10.070636	10.278226	12
49	9.721978	9.929286	9.792692	10.207308	10.070714	10.278022	11
50	9.722181	9.929207	9.792974	10.207026	10.070793	10.277819	10
51	9.722385	9.929129	9.793256	10.206744	10.070871	10.277615	9
52	9.722588	9.929050	9.793538	10.206462	10.070950	10.277412	8
53	9.722791	9.928972	9.793819	10.206181	10.071028	10.277209	7
54	9.722994	9.928893	9.794101	10.205899	10.071107	10.277006	6
55	9.723197	9.928814	9.794383	10.205617	10.071186	10.276803	5
56	9.723400	9.928736	9.794664	10.205336	10.071264	10.276600	4
57	9.723603	9.928657	9.794945	10.205055	10.071343	10.276397	3
58	9.723805	9.928578	9.795227	10.204773	10.071422	10.276195	2
59	9.724007	9.928499	9.795508	10.204492	10.071501	10.275993	1
60	9.724210	9.928420	9.795789	10.204211	10.071580	10.275790	0
		Sine		Tangent		Secant	Minutes

58 Degrees.

D d 3

32 Degrees.

Minutes	Sine		Tang.		Secant		Minutes
0	9.724210	9.928420	9.795785	10.204211	10.071580	10.275790	00
1	9.724412	9.928341	9.796070	10.203930	10.071659	10.275588	59
2	9.724614	9.928262	9.796351	10.203645	10.071738	10.275386	58
3	9.724816	9.928183	9.796632	10.203368	10.071817	10.275184	57
4	9.725017	9.928104	9.796913	10.203087	10.071896	10.274983	56
5	9.725219	9.928025	9.797194	10.202806	10.071975	10.274781	55
6	9.725420	9.927946	9.797474	10.202526	10.072054	10.274580	54
7	9.725622	9.927867	9.797755	10.202245	10.072133	10.274378	53
8	9.725823	9.927787	9.798036	10.201964	10.072213	10.274177	52
9	9.726024	9.927708	9.798316	10.201684	10.072292	10.273976	51
10	9.726225	9.927628	9.798596	10.201404	10.072372	10.273775	50
11	9.726426	9.927549	9.798877	10.201123	10.072451	10.273574	49
12	9.726626	9.927469	9.799157	10.200843	10.072531	10.273374	48
13	9.726827	9.927390	9.799437	10.200563	10.072610	10.273173	47
14	9.727027	9.927310	9.799717	10.200283	10.072690	10.272973	46
15	9.727228	9.927231	9.799997	10.200003	10.072769	10.272772	45
16	9.727428	9.927151	9.800277	10.199723	10.072849	10.272572	44
17	9.727628	9.927071	9.800557	10.199443	10.072929	10.272372	43
18	9.727828	9.926991	9.800836	10.199164	10.073009	10.272172	42
19	9.728027	9.926911	9.801116	10.198884	10.073089	10.271973	41
20	9.728227	9.926831	9.801396	10.198604	10.073169	10.271773	40
21	9.728427	9.926751	9.801675	10.198325	10.073249	10.271573	39
22	9.728626	9.926671	9.801955	10.198045	10.073329	10.271374	38
23	9.728825	9.926591	9.802234	10.197766	10.073409	10.271175	37
24	9.729024	9.926511	9.802513	10.197487	10.073489	10.270976	36
25	9.729223	9.926431	9.802792	10.197208	10.073569	10.270777	35
26	9.729422	9.926351	9.803072	10.196928	10.073649	10.270578	34
27	9.729621	9.926270	9.803351	10.196649	10.073730	10.270379	33
28	9.729816	9.926190	9.803630	10.196370	10.073810	10.270184	32
29	9.730018	9.926110	9.803908	10.196092	10.073890	10.269982	31
30	9.730210	9.926029	9.804187	10.195813	10.073971	10.269784	30
	Sine		Tangent		Secant		Minutes

57 Degrees.

Tangents, and Secants.

(423)

32 Degrees.

Minutes	Sine		Tang.		Secant		Minutes
30	9.730216	9.926029	9.804187	10.195813	10.073971	10.269744	30
31	9.730415	9.925949	9.804466	10.195534	10.074051	10.269585	29
32	9.730613	9.925868	9.804745	10.195255	10.074132	10.269387	28
33	9.730811	9.925787	9.805023	10.194977	10.074213	10.269189	27
34	9.731009	9.925707	9.805302	10.194698	10.074293	10.268991	26
35	9.731206	9.925626	9.805580	10.194420	10.074374	10.268794	25
36	9.731404	9.925545	9.805859	10.194141	10.074455	10.268596	24
37	9.731601	9.925465	9.806137	10.193863	10.074535	10.268399	23
38	9.731799	9.925384	9.806415	10.193585	10.074616	10.268201	22
39	9.731996	9.925303	9.806693	10.193307	10.074697	10.268004	21
40	9.732193	9.925222	9.806971	10.193029	10.074778	10.267807	20
41	9.732390	9.925141	9.807249	10.192751	10.074859	10.267610	19
42	9.732587	9.925060	9.807527	10.192473	10.074940	10.267413	18
43	9.732784	9.924979	9.807805	10.192195	10.075021	10.267216	17
44	9.732980	9.924897	9.808083	10.191917	10.075103	10.267020	16
45	9.733177	9.924816	9.808361	10.191639	10.075184	10.266823	15
46	9.733373	9.924735	9.808639	10.191362	10.075265	10.266627	14
47	9.733569	9.924653	9.808916	10.191084	10.075347	10.266431	13
48	9.733765	9.924572	9.809193	10.190807	10.075428	10.266235	12
49	9.733961	9.924491	9.809471	10.190529	10.075509	10.266039	11
50	9.734157	9.924409	9.809748	10.190252	10.075591	10.265843	10
51	9.734353	9.924328	9.810025	10.189975	10.075672	10.265647	9
52	9.734548	9.924246	9.810302	10.189698	10.075754	10.265452	8
53	9.734744	9.924164	9.810580	10.189420	10.075836	10.265256	7
54	9.734939	9.924083	9.810857	10.189143	10.075917	10.265061	6
55	9.735134	9.924001	9.811134	10.188866	10.075999	10.264866	5
56	9.735330	9.923919	9.811410	10.188590	10.076081	10.264670	4
57	9.735525	9.923837	9.811687	10.188313	10.076163	10.264475	3
58	9.735719	9.923755	9.811964	10.188036	10.076245	10.264281	2
59	9.735914	9.923673	9.812241	10.187759	10.076327	10.264086	1
60	9.736108	9.923591	9.812517	10.187483	10.076409	10.263891	0
	Sine		Tangent		Secant		Minutes

57 Degrees.

33 Degrees.

Minutes	Sine		Tang.		Secant		
0	9.736109	9.923591	9.81251	10.187483	10.076409	10.263891	60
1	9.736303	9.923509	9.812794	10.187201	10.076491	10.263697	59
2	9.736498	9.923427	9.813070	10.186930	10.076573	10.263502	58
3	9.736692	9.923345	9.813347	10.186653	10.076655	10.263308	57
4	9.736886	9.923263	9.813623	10.186377	10.076737	10.263114	56
5	9.737080	9.923180	9.813899	10.186101	10.076820	10.262920	55
6	9.737274	9.923098	9.814175	10.185825	10.076902	10.262726	54
7	9.737467	9.923016	9.814452	10.185548	10.076984	10.262533	53
8	9.737661	9.922933	9.814728	10.185272	10.077067	10.262339	52
9	9.737855	9.922851	9.815004	10.184996	10.077149	10.262145	51
10	9.738048	9.922768	9.815279	10.184721	10.077232	10.261952	50
11	9.738241	9.922686	9.815555	10.184445	10.077314	10.261759	49
12	9.738434	9.922603	9.815831	10.184169	10.077397	10.261566	48
13	9.738627	9.922520	9.816107	10.183893	10.077480	10.261373	47
14	9.738820	9.922438	9.816382	10.183618	10.077562	10.261180	46
15	9.739013	9.922355	9.816658	10.183342	10.077645	10.260987	45
16	9.739205	9.922272	9.816933	10.183067	10.077728	10.260795	44
17	9.739398	9.922189	9.817209	10.182791	10.077811	10.260602	43
18	9.739590	9.922106	9.817484	10.182516	10.077894	10.260410	42
19	9.739783	9.922023	9.817759	10.182241	10.077977	10.260217	41
20	9.739975	9.921940	9.818035	10.181965	10.078060	10.260025	40
21	9.740167	9.921857	9.818310	10.181690	10.078143	10.259833	39
22	9.740359	9.921774	9.818585	10.181415	10.078226	10.259641	38
23	9.740550	9.921691	9.818860	10.181140	10.078309	10.259450	37
24	9.740742	9.921607	9.819135	10.180865	10.078393	10.259258	36
25	9.740934	9.921524	9.819410	10.180590	10.078476	10.259066	35
26	9.741125	9.921441	9.819684	10.180316	10.078559	10.258875	34
27	9.741316	9.921357	9.819959	10.180041	10.078643	10.258684	33
28	9.741507	9.921274	9.820234	10.179766	10.078726	10.258493	32
29	9.741699	9.921190	9.820508	10.179492	10.078810	10.258301	31
30	9.741890	9.921107	9.820783	10.179217	10.078893	10.258111	30
	Sine		Tangent		Secant		Minutes

56 Degrees.

Tangents, and Secants.

(425)

33 Degrees.

Minutes	Sine	Tang.	Secant	
30	9.741889	9.921107	9.820783	10.179217
31	9.742080	9.921023	9.821057	10.178943
32	9.742271	9.920939	9.821332	10.178668
33	9.742462	9.920855	9.821606	10.178394
34	9.742652	9.920772	9.821880	10.178120
35	9.742842	9.920688	9.822154	10.177846
36	9.743033	9.920604	9.822429	10.177571
37	9.743223	9.920520	9.822703	10.177297
38	9.743413	9.920436	9.822977	10.177023
39	9.743602	9.920352	9.823250	10.176750
40	9.743792	9.920268	9.823524	10.176476
41	9.743982	9.920184	9.823798	10.176202
42	9.744171	9.920099	9.824072	10.175928
43	9.744361	9.920015	9.824345	10.175655
44	9.744550	9.919931	9.824619	10.175381
45	9.744739	9.919846	9.824893	10.175107
46	9.744928	9.919762	9.825166	10.174834
47	9.745117	9.919677	9.825439	10.174561
48	9.745306	9.919593	9.825713	10.174287
49	9.745494	9.919508	9.825986	10.174014
50	9.745683	9.919424	9.826259	10.173741
51	9.745871	9.919339	9.826532	10.173468
52	9.746059	9.919254	9.826805	10.173195
53	9.746248	9.919169	9.827078	10.172922
54	9.746436	9.919084	9.827351	10.172649
55	9.746624	9.919000	9.827624	10.172376
56	9.746811	9.918915	9.827897	10.172103
57	9.746999	9.918830	9.828170	10.171830
58	9.747187	9.918744	9.828442	10.171558
59	9.747374	9.918659	9.828715	10.171285
60	9.747562	9.918574	9.828987	10.171013
	Sine		Tangent	Secant

56 Degrees.

34 Degrees.

Minutes	Sine		Tang.		Secant	
0	9.747562	9.918574	9.828987	10.171013	10.081426	10.252438
1	9.747749	9.918489	9.829260	10.170740	10.081511	10.252251
2	9.747936	9.918404	9.829532	10.170468	10.081596	10.252064
3	9.748123	9.918318	9.829805	10.170195	10.081682	10.251877
4	9.748310	9.918233	9.830077	10.169923	10.081767	10.251690
5	9.748497	9.918147	9.830349	10.169651	10.081853	10.251503
6	9.748683	9.918062	9.830621	10.169379	10.081938	10.251317
7	9.748870	9.917976	9.830893	10.169107	10.082024	10.251130
8	9.749056	9.917891	9.831165	10.168835	10.082109	10.250944
9	9.749242	9.917805	9.831437	10.168563	10.082195	10.250758
10	9.749429	9.917719	9.831709	10.168291	10.082281	10.250571
11	9.749615	9.917634	9.831981	10.168019	10.082366	10.250385
12	9.749801	9.917548	9.832253	10.167747	10.082452	10.250199
13	9.749987	9.917462	9.832525	10.167475	10.082538	10.250013
14	9.750172	9.917376	9.832796	10.167204	10.082624	10.249828
15	9.750358	9.917290	9.833068	10.166932	10.082710	10.249642
16	9.750543	9.917204	9.833339	10.166661	10.082796	10.249457
17	9.750729	9.917118	9.833611	10.166389	10.082882	10.249271
18	9.750914	9.917032	9.833882	10.166118	10.082968	10.249086
19	9.751099	9.916945	9.834154	10.165846	10.083055	10.248901
20	9.751284	9.916859	9.834425	10.165575	10.083141	10.248716
21	9.751469	9.916773	9.834696	10.165304	10.083227	10.248531
22	9.751654	9.916687	9.834967	10.165033	10.083313	10.248346
23	9.751838	9.916600	9.835238	10.164762	10.083400	10.248162
24	9.752023	9.916514	9.835509	10.164491	10.083486	10.247977
25	9.752207	9.916427	9.835780	10.164220	10.083573	10.247793
26	9.752392	9.916341	9.836051	10.163949	10.083649	10.247608
27	9.752576	9.916254	9.836322	10.163678	10.083746	10.247424
28	9.752760	9.916167	9.836593	10.163407	10.083833	10.247240
29	9.752944	9.916080	9.836864	10.163136	10.083920	10.247056
30	9.753128	9.915994	9.837134	10.162866	10.084006	10.246872
	Sine		Tangent		Secant	Minutes

55 Degrees.

Tangents, and Secants.

(427)

34 Degrees.

Minutes	Sine		Tang.		Secant		Minutes
30	9.753128	9.915994	9.837134	10.162866	10.084006	10.246872	30
31	9.753312	9.915907	9.837405	10.162595	10.084093	10.246688	29
32	9.753495	9.915820	9.837675	10.162325	10.084180	10.246505	28
33	9.753679	9.915733	9.837946	10.162054	10.084267	10.246321	27
34	9.753862	9.915646	9.838216	10.161784	10.084354	10.246138	26
35	9.754046	9.915559	9.838487	10.161513	10.084441	10.245954	25
36	9.754229	9.915472	9.838757	10.161243	10.084528	10.245771	24
37	9.754412	9.915385	9.839027	10.160973	10.084615	10.245588	23
38	9.754595	9.915297	9.839297	10.160702	10.084703	10.245405	22
39	9.754778	9.915210	9.839568	10.160432	10.084790	10.245222	21
40	9.754960	9.915123	9.839838	10.160162	10.084877	10.245040	20
41	9.755143	9.915035	9.840108	10.159892	10.084965	10.244857	19
42	9.755326	9.914948	9.840378	10.159622	10.085052	10.244674	18
43	9.755508	9.914860	9.840647	10.159353	10.085140	10.244492	17
44	9.755690	9.914773	9.840917	10.159083	10.085227	10.244310	16
45	9.755872	9.914685	9.841187	10.158813	10.085315	10.244128	15
46	9.756054	9.914598	9.841457	10.158543	10.085402	10.243946	14
47	9.756236	9.914510	9.841726	10.158274	10.085490	10.243764	13
48	9.756418	9.914422	9.841996	10.158004	10.085578	10.243582	12
49	9.756600	9.914334	9.842266	10.157734	10.085666	10.243400	11
50	9.756781	9.914246	9.842535	10.157465	10.085754	10.243219	10
51	9.756963	9.914158	9.842805	10.157195	10.085842	10.243037	9
52	9.757144	9.914070	9.843074	10.156926	10.085930	10.242856	8
53	9.757326	9.913982	9.843343	10.156657	10.086018	10.242674	7
54	9.757507	9.913894	9.843612	10.156388	10.086106	10.242493	6
55	9.757688	9.913806	9.843882	10.156118	10.086194	10.242312	5
56	9.757869	9.913718	9.844151	10.155849	10.086282	10.242131	4
57	9.758049	9.913630	9.844420	10.155580	10.086370	10.241951	3
58	9.758230	9.913541	9.844689	10.155311	10.086459	10.241770	2
59	9.758411	9.913453	9.844958	10.155042	10.086547	10.241589	1
60	9.758591	9.913364	9.845227	10.154773	10.086636	10.241409	0
	Sine		Tangent		Secant		Minutes

55 Degrees.

35 Degrees.

Minutes	Sine		Tang.		Secant		Minutes
0	9.758591	9.913364	9.845227	10.154773	10.086636	10.241409	60
1	9.758772	9.913276	9.845496	10.154504	10.086724	10.241228	59
2	9.758952	9.913187	9.845764	10.154236	10.086813	10.241048	58
3	9.759132	9.913099	9.846033	10.153967	10.086901	10.240868	57
4	9.759312	9.913010	9.846302	10.153698	10.086990	10.240688	56
5	9.759492	9.912921	9.846570	10.153430	10.087079	10.240508	55
6	9.759672	9.912833	9.846839	10.153161	10.087167	10.240328	54
7	9.759851	9.912744	9.847107	10.152893	10.087256	10.240149	53
8	9.760031	9.912655	9.847376	10.152624	10.087345	10.239969	52
9	9.760211	9.912566	9.847644	10.152356	10.087434	10.239789	51
10	9.760390	9.912477	9.847913	10.152087	10.087523	10.239610	50
11	9.760569	9.912388	9.848181	10.151819	10.087612	10.239431	49
12	9.760748	9.912299	9.848449	10.151551	10.087701	10.239252	48
13	9.760927	9.912210	9.848717	10.151283	10.087790	10.239073	47
14	9.761106	9.912121	9.848985	10.151015	10.087879	10.238894	46
15	9.761285	9.912031	9.849254	10.150746	10.087969	10.238715	45
16	9.761464	9.911942	9.849522	10.150478	10.088058	10.238536	44
17	9.761642	9.911853	9.849790	10.150210	10.088147	10.238358	43
18	9.761821	9.911763	9.850057	10.149943	10.088237	10.238179	42
19	9.761999	9.911674	9.850325	10.149675	10.088326	10.238001	41
20	9.762177	9.911584	9.850593	10.149407	10.088416	10.237823	40
21	9.762356	9.911495	9.850861	10.149139	10.088505	10.237644	39
22	9.762534	9.911405	9.851128	10.148872	10.088595	10.237466	38
23	9.762712	9.911315	9.851396	10.148604	10.088685	10.237288	37
24	9.762889	9.911226	9.851664	10.148336	10.088774	10.237111	36
25	9.763067	9.911136	9.851931	10.148069	10.088864	10.236933	35
26	9.763245	9.911046	9.852199	10.147801	10.088954	10.236755	34
27	9.763422	9.910956	9.852466	10.147534	10.089044	10.236578	33
28	9.763600	9.910866	9.852733	10.147267	10.089134	10.236400	32
29	9.763777	9.910776	9.853001	10.146999	10.089224	10.236223	31
30	9.763954	9.910686	9.853268	10.146732	10.089314	10.236046	30
		Sine		Tangent		Secant	

54 Degrees.

35 Degrees.

Minutes	Sine		Tang.		Secant	
30	9.763954	9.910686	9.853268	10.146732	10.089314	10.236046 30
31	9.764131	9.910596	9.853535	10.146465	10.089404	10.235869 29
32	9.764308	9.910506	9.853802	10.146198	10.089494	10.235692 28
33	9.764485	9.910415	9.854069	10.145931	10.089585	10.235515 27
34	9.764662	9.910325	9.854336	10.145664	10.089675	10.235338 26
35	9.764838	9.910235	9.854603	10.145397	10.089765	10.235162 25
36	9.765015	9.910144	9.854870	10.145130	10.089856	10.234985 24
37	9.765191	9.910054	9.855137	10.144863	10.089946	10.234809 23
38	9.765367	9.909963	9.855404	10.144596	10.090037	10.234633 22
39	9.765544	9.909873	9.855671	10.144329	10.090127	10.234456 21
40	9.765720	9.909782	9.855938	10.144062	10.090218	10.234280 20
41	9.765896	9.909691	9.856204	10.143796	10.090309	10.234104 19
42	9.766071	9.909601	9.856471	10.143529	10.090399	10.233929 18
43	9.766247	9.909510	9.856737	10.143263	10.090490	10.233753 17
44	9.766423	9.909419	9.857004	10.142996	10.090581	10.233577 16
45	9.766598	9.909328	9.857270	10.142730	10.090672	10.233402 15
46	9.766774	9.909237	9.857537	10.142463	10.090763	10.233226 14
47	9.766949	9.909146	9.857803	10.142197	10.090854	10.233051 13
48	9.767124	9.909055	9.858069	10.141931	10.090945	10.232876 12
49	9.767300	9.908964	9.858336	10.141664	10.091036	10.232700 11
50	9.767475	9.908873	9.858602	10.141398	10.091127	10.232525 10
51	9.767649	9.908781	9.858868	10.141132	10.091219	10.232351 9
52	9.767824	9.908690	9.859134	10.140866	10.091310	10.232176 8
53	9.767999	9.908599	9.859400	10.140600	10.091401	10.232001 7
54	9.768173	9.908507	9.859666	10.140334	10.091493	10.231827 6
55	9.768348	9.908416	9.859932	10.140068	10.091584	10.231652 5
56	9.768522	9.908324	9.860198	10.139802	10.091676	10.231478 4
57	9.768697	9.908233	9.860464	10.139536	10.091767	10.231303 3
58	9.768871	9.908141	9.860730	10.139270	10.091859	10.231129 2
59	9.769045	9.908049	9.860995	10.139005	10.091951	10.230955 1
60	9.769219	9.907958	9.861261	10.138739	10.092042	10.230781 0
	Sine		Tangent		Secant	Minutes

54 Degrees.

Minutes	Sine		Tang.		Secant		
0	9.709215	9.907958	9.861261	10.138739	10.092042	10.230781	60
1	9.769392	9.907866	9.861527	10.138473	10.092134	10.230608	49
2	9.769566	9.907774	9.861792	10.138208	10.092226	10.230434	58
3	9.769740	9.907682	9.862058	10.137942	10.092318	10.230260	57
4	9.769912	9.907590	9.862323	10.137677	10.092410	10.230088	56
5	9.770087	9.907498	9.862589	10.137411	10.092502	10.229913	55
6	9.770260	9.907406	9.862854	10.137146	10.092594	10.229740	54
7	9.770433	9.907314	9.863119	10.136881	10.092686	10.229567	53
8	9.770606	9.907222	9.863385	10.136615	10.092778	10.229394	52
9	9.770779	9.907129	9.863650	10.136350	10.092871	10.229221	51
10	9.770952	9.907037	9.863915	10.136085	10.092963	10.229048	50
11	9.771125	9.906945	9.864180	10.135820	10.093055	10.228875	49
12	9.771298	9.906852	9.864445	10.135555	10.093148	10.228702	48
13	9.771470	9.906760	9.864711	10.135290	10.093240	10.228530	47
14	9.771643	9.906667	9.864975	10.135025	10.093333	10.228357	46
15	9.771815	9.906574	9.865240	10.134760	10.093426	10.228185	45
16	9.771987	9.906482	9.865505	10.134495	10.093518	10.228013	44
17	9.772159	9.906389	9.865770	10.134230	10.093611	10.227841	43
18	9.772331	9.906296	9.866035	10.133965	10.093704	10.227669	42
19	9.772503	9.906204	9.866300	10.133700	10.093796	10.227497	41
20	9.772675	9.906111	9.866564	10.133436	10.093889	10.227325	40
21	9.772847	9.906018	9.866829	10.133171	10.093982	10.227153	39
22	9.773018	9.905925	9.867094	10.132906	10.094075	10.226982	38
23	9.773190	9.905832	9.867358	10.132642	10.094168	10.226810	37
24	9.773361	9.905739	9.867623	10.132377	10.094261	10.226639	36
25	9.773533	9.905645	9.867887	10.132113	10.094355	10.226467	35
26	9.773704	9.905552	9.868152	10.131848	10.094448	10.226296	34
27	9.773875	9.905459	9.868416	10.131584	10.094541	10.226125	33
28	9.774046	9.905366	9.868680	10.131320	10.094634	10.225954	32
29	9.774217	9.905272	9.868945	10.131055	10.094728	10.225783	31
30	9.774388	9.905179	9.869209	10.130791	10.094821	10.225612	30
	Sine		Tang.		Secant		Minutes

36 Degrees.

Minutes	Sine	Tang.	Secant	
30	9.774388	9.905179	9.869209	10.130791
31	9.774558	9.905085	9.869473	10.130527
32	9.774729	9.904992	9.869737	10.130263
33	9.774899	9.904898	9.870001	10.129999
34	9.775070	9.904804	9.870265	10.129735
35	9.775240	9.904711	9.870529	10.129471
36	9.775410	9.904617	9.870793	10.129207
37	9.775580	9.904523	9.871057	10.128943
38	9.775750	9.904429	9.871321	10.128679
39	9.775920	9.904335	9.871585	10.128415
40	9.776090	9.904241	9.871849	10.128151
41	9.776259	9.904147	9.872112	10.127888
42	9.776429	9.904053	9.872376	10.127624
43	9.776598	9.903959	9.872640	10.127360
44	9.776768	9.903864	9.872903	10.127097
45	9.776937	9.903770	9.873167	10.126833
46	9.777106	9.903676	9.873430	10.126570
47	9.777275	9.903581	9.873694	10.126306
48	9.777444	9.903487	9.873957	10.126043
49	9.777613	9.903392	9.874220	10.125780
50	9.777781	9.903298	9.874484	10.125516
51	9.777950	9.903203	9.874747	10.125253
52	9.778119	9.903108	9.875010	10.124990
53	9.778287	9.903014	9.875273	10.124727
54	9.778455	9.902919	9.875536	10.124464
55	9.778623	9.902824	9.875800	10.124200
56	9.778792	9.902729	9.876063	10.123937
57	9.778960	9.902634	9.876326	10.123674
58	9.779128	9.902539	9.876589	10.123411
59	9.779295	9.902444	9.876851	10.123149
60	9.779463	9.902349	9.877114	10.122886
	Sine	Tangent	Secant	Minutes

53 Degrees.

37 Degrees.

Minutes	Sine		Tang.		Secant		Minutes
0	9.779403	9.902349	9.877114	10.122886	10.097651	10.220537	50
1	9.779631	9.902253	9.877377	10.122622	10.097747	10.220369	49
2	9.779798	9.902158	9.877640	10.122360	10.097842	10.220202	58
3	9.779965	9.902063	9.877903	10.122097	10.097937	10.220035	57
4	9.780133	9.901967	9.878165	10.121835	10.098033	10.219867	56
5	9.780300	9.901872	9.878428	10.121572	10.098128	10.219700	55
6	9.780467	9.901776	9.878691	10.121309	10.098224	10.219533	54
7	9.780634	9.901681	9.878953	10.121047	10.098319	10.219366	53
8	9.780801	9.901585	9.879216	10.120784	10.098415	10.219199	52
9	9.780968	9.901489	9.879478	10.120522	10.098511	10.219032	51
10	9.781134	9.901394	9.879741	10.120259	10.098606	10.218866	50
11	9.781301	9.901298	9.880003	10.119997	10.098702	10.218699	49
12	9.781467	9.901202	9.880265	10.119735	10.098798	10.218533	48
13	9.781634	9.901106	9.880528	10.119472	10.098894	10.218366	47
14	9.781800	9.901010	9.880790	10.119210	10.098990	10.218200	46
15	9.781966	9.900914	9.881052	10.118948	10.099086	10.218034	45
16	9.782132	9.900818	9.881314	10.118686	10.099182	10.217868	44
17	9.782298	9.900722	9.881576	10.118424	10.099278	10.217702	43
18	9.782464	9.900626	9.881839	10.118161	10.099374	10.217536	42
19	9.782630	9.900529	9.882101	10.117899	10.099471	10.217370	41
20	9.782796	9.900433	9.882363	10.117637	10.099567	10.217204	40
21	9.782961	9.900337	9.882625	10.117375	10.099663	10.217039	39
22	9.783127	9.900240	9.882887	10.117113	10.099760	10.216873	38
23	9.783292	9.900144	9.883148	10.116852	10.099856	10.216708	37
24	9.783457	9.900047	9.883410	10.116590	10.099953	10.216543	36
25	9.783623	9.899951	9.883672	10.116328	10.100049	10.216377	35
26	9.783788	9.899854	9.883934	10.116066	10.100146	10.216212	34
27	9.783953	9.899757	9.884196	10.115804	10.100243	10.216047	33
28	9.784118	9.899660	9.884457	10.115543	10.100340	10.215882	32
29	9.784282	9.899564	9.884719	10.115281	10.100436	10.215718	31
30	9.784447	9.899467	9.884980	10.115020	10.100533	10.215553	30
	Sine		Tang.		Secant		Minutes

52 Degrees.

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Tangents, and Secants.

(433)

37 Degrees.

Minutes	Sine	Tang.	Secant	Minutes		
30	9.784447	9.899467	10.115020	10.100533	10.215553	c
31	9.784612	9.899370	10.114758	10.100630	10.215388	29
32	9.784776	9.899273	10.114497	10.100727	10.215224	28
33	9.784941	9.899176	10.114235	10.100824	10.215059	27
34	9.785105	9.899078	10.113974	10.100922	10.214895	26
35	9.785269	9.898981	10.113712	10.101019	10.214731	25
36	9.785433	9.898884	10.113451	10.101116	10.214567	24
37	9.785597	9.898787	10.113190	10.101213	10.214403	23
38	9.785761	9.898689	10.112928	10.101311	10.214239	22
39	9.785925	9.898592	10.112667	10.101409	10.214075	21
40	9.786089	9.898494	10.112406	10.101506	10.213911	20
41	9.786252	9.898397	10.112145	10.101603	10.213748	19
42	9.786416	9.898299	10.111884	10.101701	10.213584	18
43	9.786579	9.898202	10.111623	10.101798	10.213421	17
44	9.786742	9.898104	10.111361	10.101896	10.213258	16
45	9.786906	9.898006	10.111100	10.101994	10.213094	15
46	9.787069	9.897908	10.110840	10.102092	10.212931	14
47	9.787232	9.897810	10.110579	10.102190	10.212768	13
48	9.787395	9.897712	10.110318	10.102288	10.212605	12
49	9.787557	9.897614	10.110057	10.102386	10.212443	11
50	9.787720	9.897516	10.109796	10.102484	10.212280	10
51	9.787883	9.897418	10.109535	10.102582	10.212117	9
52	9.788045	9.897320	10.109275	10.102680	10.211955	8
53	9.788208	9.897222	10.109014	10.102778	10.211792	7
54	9.788370	9.897123	10.108753	10.102877	10.211630	6
55	9.788532	9.897025	10.108493	10.102975	10.211468	5
56	9.788694	9.896926	10.108232	10.103074	10.211306	4
57	9.788856	9.896828	10.107972	10.103172	10.211144	3
58	9.789018	9.896729	10.107711	10.103271	10.210982	2
59	9.789180	9.896631	10.107451	10.103369	10.210820	1
60	9.789342	9.896532	10.107190	10.103468	10.210658	0
	Sine	Tang.	Secant			

52 Degrees.

E c

A Table of Artificial Sines,
38 Degrees.

Minutes	Sine	Tang.	Secant	Minutes
0	9.78434	9.89653	10.10719	0
1	9.78950	9.89643	10.10693	1
2	9.78966	9.89635	10.10669	2
3	9.78982	9.89626	10.10640	3
4	9.78998	9.89617	10.10614	4
5	9.79014	9.89608	10.10589	5
6	9.79031	9.89599	10.10562	6
7	9.79047	9.89584	10.10536	7
8	9.79063	9.89574	10.10510	8
9	9.79079	9.89564	10.10484	9
10	9.79095	9.89554	10.10458	10
11	9.79111	9.89544	10.10432	11
12	9.79127	9.89534	10.10406	12
13	9.79143	9.89524	10.10380	13
14	9.79159	9.89514	10.10354	14
15	9.79175	9.89504	10.10328	15
16	9.79191	9.89494	10.10302	16
17	9.79207	9.89484	10.10276	17
18	9.79223	9.89474	10.10250	18
19	9.79239	9.89464	10.10224	19
20	9.79255	9.89454	10.10198	20
21	9.79271	9.89444	10.10172	21
22	9.79287	9.89434	10.10146	22
23	9.79303	9.89424	10.10120	23
24	9.79319	9.89414	10.10094	24
25	9.79335	9.89404	10.10068	25
26	9.79351	9.89394	10.10042	26
27	9.79367	9.89384	10.10016	27
28	9.79383	9.89374	10.09990	28
29	9.79399	9.89364	10.09964	29
30	9.79415	9.89354	10.09938	30
	Sine	Tang.	Secant	Minutes

51 Degrees.

38 Degrees.

Minutes	Sine	Tang.	Secant	Minutes
30	9.794150	9.893544	9.900605	10
31	9.794308	9.893444	9.900864	29
32	9.794467	9.893343	9.901124	28
33	9.794626	9.893243	9.901383	27
34	9.794784	9.893142	9.901642	26
35	9.794942	9.893041	9.901901	25
36	9.795101	9.892940	9.902160	24
37	9.795259	9.892839	9.902419	23
38	9.795417	9.892738	9.902679	22
39	9.795575	9.892637	9.902938	21
40	9.795733	9.892536	9.903197	20
41	9.795891	9.892435	9.903455	19
42	9.796049	9.892334	9.903714	18
43	9.796206	9.892233	9.903973	17
44	9.796364	9.892132	9.904232	16
45	9.796521	9.892030	9.904491	15
46	9.796679	9.891929	9.904750	14
47	9.796836	9.891827	9.905008	13
48	9.796993	9.891726	9.905267	12
49	9.797150	9.891624	9.905526	11
50	9.797307	9.891523	9.905784	10
51	9.797464	9.891421	9.906043	9
52	9.797621	9.891319	9.906302	8
53	9.797777	9.891217	9.906560	7
54	9.797934	9.891115	9.906819	6
55	9.798091	9.891013	9.907077	5
56	9.798247	9.890912	9.907336	4
57	9.798403	9.890809	9.907594	3
58	9.798560	9.890707	9.907852	2
59	9.798716	9.890605	9.908111	1
60	9.798872	9.890503	9.908369	0
	Sine	Tang.	Secant	Minutes

51 Degrees.

Mins.	Sine	Tang.	Secant	
1	9.798872	9.890503	9.908369	10.091031
2	9.799028	9.890400	9.908627	10.091373
3	9.799184	9.890298	9.908886	10.091714
4	9.799339	9.890195	9.909144	10.092056
5	9.799495	9.890093	9.909402	10.092398
6	9.799651	9.889990	9.909660	10.092740
7	9.799806	9.889888	9.909918	10.093082
8	9.799962	9.889785	9.910177	10.093423
9	9.800117	9.889682	9.910435	10.093765
10	9.800272	9.889579	9.910693	10.094107
11	9.800427	9.889476	9.910951	10.094449
12	9.800582	9.889374	9.911209	10.094791
13	9.800737	9.889271	9.911467	10.095133
14	9.800892	9.889167	9.911724	10.095475
15	9.801047	9.889064	9.911982	10.095817
16	9.801201	9.888961	9.912240	10.096159
17	9.801356	9.888858	9.912498	10.096501
18	9.801511	9.888755	9.912756	10.096843
19	9.801665	9.888651	9.913014	10.097185
20	9.801819	9.888548	9.913271	10.097527
21	9.801973	9.888444	9.913529	10.097869
22	9.802128	9.888341	9.913787	10.098211
23	9.802282	9.888237	9.914044	10.098553
24	9.802435	9.888133	9.914302	10.098895
25	9.802589	9.888030	9.914560	10.099237
26	9.802743	9.887926	9.914817	10.099579
27	9.802897	9.887822	9.915075	10.099921
28	9.803050	9.887718	9.915332	10.100263
29	9.803204	9.887614	9.915590	10.100605
30	9.803357	9.887510	9.915847	10.100947
31	9.803510	9.887406	9.916104	10.101289
32	9.803663	9.887302	9.916361	10.101631
33	9.803816	9.887198	9.916619	10.101973
34	9.803969	9.887094	9.916876	10.102315
35	9.804122	9.886990	9.917133	10.102657
36	9.804275	9.886886	9.917390	10.103000
37	9.804428	9.886782	9.917647	10.103342
38	9.804581	9.886678	9.917904	10.103684
39	9.804734	9.886574	9.918161	10.104026
40	9.804887	9.886470	9.918418	10.104368
41	9.805040	9.886366	9.918675	10.104710
42	9.805193	9.886262	9.918932	10.105052
43	9.805346	9.886158	9.919189	10.105394
44	9.805499	9.886054	9.919446	10.105736
45	9.805652	9.885950	9.919703	10.106078
46	9.805805	9.885846	9.919960	10.106420
47	9.805958	9.885742	9.920217	10.106762
48	9.806111	9.885638	9.920474	10.107104
49	9.806264	9.885534	9.920731	10.107446
50	9.806417	9.885430	9.920988	10.107788
51	9.806570	9.885326	9.921245	10.108130
52	9.806723	9.885222	9.921502	10.108472
53	9.806876	9.885118	9.921759	10.108814
54	9.807029	9.885014	9.922016	10.109156
55	9.807182	9.884910	9.922273	10.109498
56	9.807335	9.884806	9.922530	10.109840
57	9.807488	9.884702	9.922787	10.110182
58	9.807641	9.884598	9.923044	10.110524
59	9.807794	9.884494	9.923301	10.110866
60	9.807947	9.884390	9.923558	10.111208
61	9.808100	9.884286	9.923815	10.111550
62	9.808253	9.884182	9.924072	10.111892
63	9.808406	9.884078	9.924329	10.112234
64	9.808559	9.883974	9.924586	10.112576
65	9.808712	9.883870	9.924843	10.112918
66	9.808865	9.883766	9.925100	10.113260
67	9.809018	9.883662	9.925357	10.113602
68	9.809171	9.883558	9.925614	10.113944
69	9.809324	9.883454	9.925871	10.114286
70	9.809477	9.883350	9.926128	10.114628
71	9.809630	9.883246	9.926385	10.114970
72	9.809783	9.883142	9.926642	10.115312
73	9.809936	9.883038	9.926899	10.115654
74	9.810089	9.882934	9.927156	10.115996
75	9.810242	9.882830	9.927413	10.116338
76	9.810395	9.882726	9.927670	10.116680
77	9.810548	9.882622	9.927927	10.117022
78	9.810701	9.882518	9.928184	10.117364
79	9.810854	9.882414	9.928441	10.117706
80	9.811007	9.882310	9.928698	10.118048
81	9.811160	9.882206	9.928955	10.118390
82	9.811313	9.882102	9.929212	10.118732
83	9.811466	9.882000	9.929469	10.119074
84	9.811619	9.881896	9.929726	10.119416
85	9.811772	9.881792	9.929983	10.119758
86	9.811925	9.881688	9.930240	10.120100
87	9.812078	9.881584	9.930497	10.120442
88	9.812231	9.881480	9.930754	10.120784
89	9.812384	9.881376	9.931011	10.121126
90	9.812537	9.881272	9.931268	10.121468
91	9.812690	9.881168	9.931525	10.121810
92	9.812843	9.881064	9.931782	10.122152
93	9.812996	9.880960	9.932039	10.122494
94	9.813149	9.880856	9.932296	10.122836
95	9.813302	9.880752	9.932553	10.123178
96	9.813455	9.880648	9.932810	10.123520
97	9.813608	9.880544	9.933067	10.123862
98	9.813761	9.880440	9.933324	10.124204
99	9.813914	9.880336	9.933581	10.124546
100	9.814067	9.880232	9.933838	10.124888
101	9.814220	9.880128	9.934095	10.125230
102	9.814373	9.880024	9.934352	10.125572
103	9.814526	9.879920	9.934609	10.125914
104	9.814679	9.879816	9.934866	10.126256
105	9.814832	9.879712	9.935123	10.126598
106	9.814985	9.879608	9.935380	10.126940
107	9.815138	9.879504	9.935637	10.127282
108	9.815291	9.879400	9.935894	10.127624
109	9.815444	9.879296	9.936151	10.127966
110	9.815597	9.879192	9.936408	10.128308
111	9.815750	9.879088	9.936665	10.128650
112	9.815903	9.878984	9.936922	10.128992
113	9.816056	9.878880	9.937179	10.129334
114	9.816209	9.878776	9.937436	10.129676
115	9.816362	9.878672	9.937693	10.130018
116	9.816515	9.878568	9.937950	10.130360
117	9.816668	9.878464	9.938207	10.130702
118	9.816821	9.878360	9.938464	10.131044
119	9.816974	9.878256	9.938721	10.131386
120	9.817127	9.878152	9.938978	10.131728
121	9.817280	9.878048	9.939235	10.132070
122	9.817433	9.877944	9.939492	10.132412
123	9.817586	9.877840	9.939749	10.132754
124	9.817739	9.877736	9.939999	10.133096
125	9.817892	9.877632	9.940256	10.133438
126	9.818045	9.877528	9.940513	10.133780
127	9.818198	9.877424	9.940770	10.134122
128	9.818351	9.877320	9.941027	10.134464
129	9.818504	9.877216	9.941284	10.134806
130	9.818657	9.877112	9.941541	10.135148
131	9.818810	9.877008	9.941798	10.135490
132	9.818963	9.876904	9.942055	10.135832
133	9.819116	9.876800	9.942312	10.136174
134	9.819269	9.876696	9.942569	10.136516
135	9.819422	9.876592	9.942826	10.136858
136	9.819575	9.876488	9.943083	10.137200
137	9.819728	9.876384	9.943340	10.137542
138	9.819881	9.876280	9.943597	10.137884
139	9.820034	9.876176	9.943854	10.138226
140	9.820187	9.876072	9.944111	10.138568
141	9.820340	9.875968	9.944368	10.138910
142	9.820493	9.875864	9.944625	10.139252
143	9.820646	9.875760	9.944882	10.139594
144	9.820799	9.875656	9.945139	10.139936
145	9.820952	9.875552	9.945396	10.140278
146	9.821105	9.875448	9.945653	10.140620
147	9.821258	9.875344	9.945910	10.140962
148	9.821411	9.875240	9.946167	10.141304
149	9.821564	9.875136	9.946424	10.141646
150	9.821717	9.875032	9.946681	10.141988
151	9.821870	9.874928	9.946938	10.142330
152	9.822023	9.874824	9.947195	10.142672
153	9.822176	9.874720	9.947452	10.143014
154	9.822329	9.874616	9.947709	10.143356
155	9.822482	9.874512	9.947966	10.143698
156	9.822635	9.874408	9.948223	10.144040
157	9.822788	9.874304	9.948480	10.144382
158	9.822941	9.874200	9.948737	10.144724
159	9.823094	9.874096	9.948994	10.145066
160	9.823247	9.873992	9.949251	10.145408
161	9.823400	9.873888	9.949508	10.145750
162	9.823553	9.873784	9.949765	10.146092
163	9.823706	9.873680	9.950022	10.146434
164	9.823859	9.873576	9.950279	10.146776
165	9.824012	9.873472	9.950536	10.147118
166	9.824165	9.873368	9.950793	10.147460
167	9.824318	9.873264	9.951050	10.147802
168	9.824471	9.873160	9.951307	10.148144
169	9.824624	9.873056	9.951564	10.148486
170	9.824777	9.872952	9.951821	10.148828
171	9.824930	9.872848	9.952078	10.149170
172	9.825083	9.872744	9.952335	10.149512
173	9.825236	9.872640	9.952592	10.149854
174	9.825389	9.872536	9.952849	10.150196
175	9.825542	9.872432	9.953106	10.150538
176	9.825695	9.872328	9.953363	10.150880
177	9.825848	9.872224	9.953620	10.151222
178	9.826001	9.872120	9.953877	10.151564
179	9.826154	9.872016	9.954134	10.151906
180	9.826307	9.871912	9.954391	10.152248
181	9.826460	9.871808	9.954648	10.152590
182	9.826613	9.871704	9.954905	10.152932
183	9.826766	9.871600	9.955162	10.153274
184	9.826919	9.871496	9.955419	10.153616
185	9.827072	9.871392	9.955676	10.153958
186	9.827225	9.871288	9.955933	10.154300
187	9.827378	9.871184	9.9561	

39 Degrees.

Minute	Sine	Tang.	Secant	Minute		
30	9.803510	9.827406	9.916104	10.083896	10.112594	10.196490
31	9.803664	9.827302	9.916362	10.083638	10.112698	10.196336
32	9.803817	9.827198	9.916619	10.083381	10.112802	10.196183
33	9.803970	9.827093	9.916876	10.083124	10.112907	10.196030
34	9.804123	9.826989	9.917134	10.082866	10.113011	10.195877
35	9.804276	9.826885	9.917391	10.082605	10.113115	10.195724
36	9.804428	9.826780	9.917648	10.082352	10.113220	10.195572
37	9.804581	9.826676	9.917905	10.082095	10.113324	10.195419
38	9.804734	9.826571	9.918163	10.081837	10.113429	10.195266
39	9.804886	9.826466	9.918420	10.081580	10.113534	10.195114
40	9.805038	9.826362	9.918677	10.081323	10.113638	10.194962
41	9.805191	9.826257	9.918934	10.081066	10.113743	10.194809
42	9.805343	9.826152	9.919191	10.080805	10.113848	10.194657
43	9.805495	9.826047	9.919448	10.080552	10.113953	10.194505
44	9.805647	9.825942	9.919705	10.080295	10.114058	10.194353
45	9.805799	9.825837	9.919962	10.080038	10.114163	10.194201
46	9.805951	9.825732	9.920219	10.079781	10.114268	10.194049
47	9.806103	9.825627	9.920476	10.079524	10.114373	10.193897
48	9.806254	9.825521	9.920733	10.079267	10.114479	10.193746
49	9.806406	9.825416	9.920990	10.079010	10.114584	10.193594
50	9.806557	9.825311	9.921247	10.078753	10.114689	10.193443
51	9.806709	9.825205	9.921503	10.078497	10.114795	10.193291
52	9.806860	9.825100	9.921760	10.078240	10.114900	10.193140
53	9.807011	9.824994	9.922017	10.077983	10.115006	10.192989
54	9.807163	9.824889	9.922274	10.077726	10.115111	10.192837
55	9.807314	9.824783	9.922530	10.077470	10.115217	10.192686
56	9.807465	9.824677	9.922787	10.077215	10.115323	10.192535
57	9.807615	9.824572	9.923044	10.076956	10.115428	10.192385
58	9.807766	9.824466	9.923300	10.076700	10.115534	10.192234
59	9.807917	9.824360	9.923557	10.076443	10.115640	10.192083
60	9.808067	9.824254	9.923813	10.076187	10.115746	10.191933
	Sine	Tangent	Secant	Minute		

50 Degrees.

(438) A Table of Artificial Sines,

40 Degrees.

Minutes	Sine	Tang.	Secant				
0	9.808068	9.884254	9.923813	10.076187	10.115746	10.191932	60
1	9.808218	9.884148	9.924070	10.075930	10.115852	10.191782	59
2	9.808368	9.884042	9.924327	10.075673	10.115958	10.191632	58
3	9.808519	9.883936	9.924583	10.075417	10.116064	10.191481	57
4	9.808669	9.883829	9.924840	10.075160	10.116171	10.191331	56
5	9.808819	9.883723	9.925096	10.074904	10.116277	10.191181	55
6	9.808969	9.883617	9.925352	10.074648	10.116383	10.191031	54
7	9.809119	9.883510	9.925609	10.074391	10.116490	10.190881	53
8	9.809269	9.883404	9.925865	10.074135	10.116596	10.190731	52
9	9.809419	9.883297	9.926121	10.073879	10.116703	10.190581	51
10	9.809569	9.883191	9.926378	10.073622	10.116809	10.190431	50
11	9.809718	9.883084	9.926634	10.073366	10.116916	10.190282	49
12	9.809868	9.882977	9.926890	10.073110	10.117023	10.190132	48
13	9.810017	9.882871	9.927147	10.072853	10.117129	10.189983	47
14	9.810167	9.882764	9.927403	10.072597	10.117236	10.189833	46
15	9.810316	9.882657	9.927659	10.072341	10.117343	10.189684	45
16	9.810465	9.882550	9.927915	10.072085	10.117450	10.189535	44
17	9.810614	9.882443	9.928171	10.071829	10.117557	10.189386	43
18	9.810763	9.882336	9.928427	10.071573	10.117664	10.189237	42
19	9.810912	9.882228	9.928683	10.071317	10.117772	10.189088	41
20	9.811061	9.882121	9.928940	10.071060	10.117879	10.188939	40
21	9.811210	9.882014	9.929196	10.070804	10.117986	10.188790	39
22	9.811358	9.881907	9.929452	10.070548	10.118093	10.188642	38
23	9.811507	9.881799	9.929708	10.070292	10.118201	10.188493	37
24	9.811655	9.881692	9.929964	10.070036	10.118308	10.188345	36
25	9.811804	9.881584	9.930219	10.069781	10.118416	10.188196	35
26	9.811952	9.881477	9.930475	10.069525	10.118523	10.188048	34
27	9.812100	9.881369	9.930731	10.069269	10.118631	10.187900	33
28	9.812248	9.881261	9.930987	10.069013	10.118739	10.187752	32
29	9.812397	9.881153	9.931243	10.068757	10.118847	10.187603	31
30	9.812544	9.881046	9.931499	10.068501	10.118955	10.187456	30
	Sine		Tangent		Secant		Minutes

49 Degrees.

40 Degrees,

Minutes	Sine		Tang.		Secant		Minutes
30	9.812544	9.881045	9.931499	10.068501	10.118955	10.187456	30
31	9.812692	9.880938	9.931755	10.068245	10.119062	10.187308	29
32	9.812840	9.880830	9.932010	10.067990	10.119170	10.187160	28
33	9.812988	9.880721	9.932266	10.067734	10.119279	10.187012	27
34	9.813135	9.880613	9.932522	10.067478	10.119387	10.186865	26
35	9.813283	9.880505	9.932778	10.067222	10.119495	10.186717	25
36	9.813430	9.880397	9.933033	10.066967	10.119603	10.186570	24
37	9.813578	9.880289	9.933289	10.066711	10.119711	10.186422	23
38	9.813725	9.880180	9.933545	10.066455	10.119820	10.186275	22
39	9.813872	9.880072	9.933800	10.066200	10.119928	10.186128	21
40	9.814019	9.879963	9.934056	10.065944	10.120037	10.185981	20
41	9.814166	9.879855	9.934311	10.065689	10.120145	10.185834	19
42	9.814313	9.879746	9.934567	10.065433	10.120254	10.185687	18
43	9.814460	9.879637	9.934823	10.065177	10.120363	10.185540	17
44	9.814607	9.879529	9.935078	10.064922	10.120471	10.185393	16
45	9.814753	9.879420	9.935333	10.064667	10.120580	10.185247	15
46	9.814900	9.879311	9.935589	10.064411	10.120689	10.185100	14
47	9.815046	9.879202	9.935844	10.064156	10.120798	10.184954	13
48	9.815193	9.879093	9.936100	10.063900	10.120907	10.184807	12
49	9.815339	9.878984	9.936355	10.063645	10.121016	10.184661	11
50	9.815485	9.878875	9.936610	10.063390	10.121125	10.184515	10
51	9.815631	9.878766	9.936866	10.063134	10.121234	10.184369	9
52	9.815778	9.878656	9.937121	10.062879	10.121344	10.184222	8
53	9.815923	9.878547	9.937376	10.062624	10.121453	10.184077	7
54	9.816069	9.878438	9.937632	10.062368	10.121562	10.183931	6
55	9.816215	9.878328	9.937887	10.062113	10.121672	10.183785	5
56	9.816361	9.878219	9.938142	10.061858	10.121781	10.183639	4
57	9.816507	9.878109	9.938397	10.061602	10.121891	10.183493	3
58	9.816652	9.877999	9.938653	10.061347	10.122001	10.183348	2
59	9.816797	9.877890	9.938908	10.061092	10.122110	10.183203	1
60	9.816943	9.877780	9.939163	10.060837	10.122220	10.183057	0
	Sine		Tangent		Secant		Minutes

49 Degrees,

41 Degrees.

Minutes	Sine	Tang.	Secant	
0	9.816943	9.877780	9.939163	10.060837
1	9.817088	9.877670	9.939418	10.060582
2	9.817233	9.877560	9.939673	10.060327
3	9.817378	9.877450	9.939928	10.060072
4	9.817523	9.877340	9.940183	10.059817
5	9.817668	9.877230	9.940438	10.059562
6	9.817813	9.877120	9.940694	10.059306
7	9.817958	9.877010	9.940949	10.059051
8	9.818103	9.876899	9.941204	10.058796
9	9.818247	9.876789	9.941458	10.058542
10	9.818392	9.876678	9.941713	10.058287
11	9.818536	9.876568	9.941968	10.058032
12	9.818681	9.876457	9.942223	10.057777
13	9.818825	9.876347	9.942478	10.057522
14	9.818969	9.876236	9.942733	10.057267
15	9.819113	9.876125	9.942988	10.057012
16	9.819257	9.876014	9.943243	10.056757
17	9.819401	9.875904	9.943498	10.056502
18	9.819545	9.875793	9.943752	10.056248
19	9.819689	9.875682	9.944007	10.055993
20	9.819832	9.875571	9.944262	10.055738
21	9.819976	9.875459	9.944517	10.055483
22	9.820120	9.875348	9.944772	10.055229
23	9.820263	9.875237	9.945026	10.054974
24	9.820406	9.875126	9.945281	10.054719
25	9.820550	9.875014	9.945535	10.054465
26	9.820693	9.874903	9.945790	10.054210
27	9.820836	9.874791	9.946045	10.053955
28	9.820979	9.874679	9.946299	10.053701
29	9.821122	9.874568	9.946554	10.053446
30	9.821265	9.874456	9.946808	10.053192
		Sine	Tangent	Secant

48 Degrees.

Tangents, and Secants.

(444)

41 Degrees.

Minutes	Sine	Tang.	Secant	Minutes			
30	9.821265	9.874456	9.946808	10.053192	10.125544	10.178735	30
31	9.821407	9.874344	9.947063	10.052937	10.125656	10.178593	29
32	9.821550	9.874232	9.947317	10.052683	10.125768	10.178450	28
33	9.821693	9.874120	9.947572	10.052428	10.125880	10.178307	27
34	9.821835	9.874008	9.947826	10.052174	10.125992	10.178165	26
35	9.821977	9.873896	9.948081	10.051919	10.126104	10.178023	25
36	9.822120	9.873784	9.948335	10.051665	10.126216	10.177880	24
37	9.822262	9.873672	9.948590	10.051410	10.126328	10.177738	23
38	9.822404	9.873560	9.948844	10.051156	10.126440	10.177596	22
39	9.822546	9.873448	9.949099	10.050901	10.126552	10.177454	21
40	9.822688	9.873335	9.949353	10.050647	10.126665	10.177312	20
41	9.822830	9.873223	9.949607	10.050393	10.126777	10.177170	19
42	9.822972	9.873110	9.949862	10.050138	10.126890	10.177028	18
43	9.823114	9.872998	9.950116	10.049884	10.127002	10.176886	17
44	9.823255	9.872885	9.950370	10.049630	10.127115	10.176745	16
45	9.823397	9.872772	9.950625	10.049375	10.127228	10.176603	15
46	9.823539	9.872659	9.950879	10.049121	10.127341	10.176461	14
47	9.823680	9.872547	9.951133	10.048867	10.127453	10.176320	13
48	9.823821	9.872434	9.951388	10.048612	10.127566	10.176179	12
49	9.823963	9.872321	9.951642	10.048358	10.127679	10.176037	11
50	9.824104	9.872208	9.951896	10.048104	10.127792	10.175896	10
51	9.824245	9.872094	9.952150	10.047850	10.127906	10.175755	9
52	9.824386	9.871981	9.952404	10.047596	10.128019	10.175614	8
53	9.824527	9.871868	9.952659	10.047341	10.128132	10.175473	7
54	9.824668	9.871755	9.952913	10.047087	10.128245	10.175332	6
55	9.824808	9.871641	9.953167	10.046833	10.128359	10.175192	5
56	9.824949	9.871528	9.953421	10.046579	10.128472	10.175051	4
57	9.825090	9.871414	9.953675	10.046325	10.128586	10.174910	3
58	9.825230	9.871301	9.953929	10.046071	10.128699	10.174770	2
59	9.825370	9.871187	9.954183	10.045817	10.128813	10.174630	1
60	9.825511	9.871073	9.954437	10.045563	10.128927	10.174489	0
	Sine	Tangent	Secant				

48 Degrees.

42 Degrees.

Minutes	Sine		Tang.		Secant	
0	9.825511	9.871073	9.954437	10.045563	10.128927	10.174489
1	9.825651	9.870960	9.954691	10.045309	10.129040	10.174349
2	9.825791	9.870846	9.954945	10.045055	10.129154	10.174209
3	9.825931	9.870732	9.955199	10.044801	10.129268	10.174069
4	9.826071	9.870618	9.955453	10.044547	10.129382	10.173929
5	9.826211	9.870504	9.955707	10.044293	10.129496	10.173789
6	9.826351	9.870390	9.955961	10.044039	10.129610	10.173649
7	9.826491	9.870276	9.956215	10.043785	10.129724	10.173509
8	9.826631	9.870161	9.956469	10.043531	10.129839	10.173369
9	9.826770	9.870047	9.956723	10.043277	10.129953	10.173230
10	9.826910	9.869933	9.956977	10.043023	10.130067	10.173090
11	9.827049	9.869818	9.957231	10.042769	10.130182	10.172951
12	9.827189	9.869704	9.957485	10.042515	10.130296	10.172811
13	9.827328	9.869589	9.957739	10.042261	10.130411	10.172672
14	9.827467	9.869474	9.957993	10.042007	10.130526	10.172533
15	9.827606	9.869360	9.958246	10.041754	10.130640	10.172394
16	9.827745	9.869245	9.958500	10.041500	10.130755	10.172255
17	9.827884	9.869130	9.958754	10.041246	10.130870	10.172116
18	9.828023	9.869015	9.959008	10.040992	10.130985	10.171977
19	9.828162	9.868900	9.959262	10.040738	10.131100	10.171838
20	9.828301	9.868785	9.959515	10.040485	10.131215	10.171699
21	9.828439	9.868670	9.959769	10.040231	10.131330	10.171561
22	9.828578	9.868555	9.960023	10.039977	10.131445	10.171422
23	9.828716	9.868440	9.960277	10.039723	10.131560	10.171284
24	9.828855	9.868324	9.960530	10.039470	10.131676	10.171145
25	9.828993	9.868209	9.960784	10.039216	10.131791	10.171007
26	9.829131	9.868093	9.961038	10.038962	10.131907	10.170869
27	9.829269	9.867978	9.961291	10.038709	10.132022	10.170731
28	9.829407	9.867862	9.961545	10.038455	10.132138	10.170593
29	9.829545	9.867747	9.961799	10.038201	10.132253	10.170455
30	9.829683	9.867631	9.962052	10.037948	10.132369	10.170317
	Sine		Tangent		Secant	Minutes

47 Degrees.

42 Degrees.

Minutes	Sine	Tang.	Secant	
30	9.829683	9.867531	9.962052	10.037948
31	9.829821	9.867515	9.962306	10.037694
32	9.829959	9.867399	9.962560	10.037440
33	9.830097	9.867283	9.962813	10.037187
34	9.830234	9.867167	9.963067	10.036933
35	9.830372	9.867051	9.963320	10.036680
36	9.830509	9.866935	9.963574	10.036426
37	9.830646	9.866819	9.963827	10.036173
38	9.830784	9.866703	9.964081	10.035919
39	9.830921	9.866586	9.964335	10.035665
40	9.831058	9.866470	9.964588	10.035412
41	9.831195	9.866353	9.964842	10.035158
42	9.831332	9.866237	9.965095	10.034905
43	9.831469	9.866120	9.965349	10.034651
44	9.831606	9.866004	9.965602	10.034398
45	9.831742	9.865887	9.965855	10.034145
46	9.831879	9.865770	9.966109	10.033891
47	9.832015	9.865653	9.966362	10.033638
48	9.832152	9.865536	9.966616	10.033384
49	9.832288	9.865419	9.966869	10.033131
50	9.832425	9.865302	9.967122	10.032878
51	9.832561	9.865185	9.967376	10.032624
52	9.832697	9.865068	9.967630	10.032370
53	9.832833	9.864950	9.967883	10.032117
54	9.832969	9.864833	9.968136	10.031864
55	9.833105	9.864716	9.968389	10.031611
56	9.833241	9.864598	9.968643	10.031357
57	9.833377	9.864481	9.968896	10.031104
58	9.833512	9.864363	9.969149	10.030851
59	9.833648	9.864245	9.969402	10.030597
60	9.833783	9.864127	9.969655	10.030344
	Sine	Tangent		Secant

47 Degrees.

43 Degrees.

Minutes	Sine		Tang.		Secant		Minutes
0	9.833783	9.864127	9.969656	10.030344	10.135873	10.166217	60
1	9.833919	9.864010	9.969909	10.030091	10.135990	10.166081	59
2	9.834054	9.863892	9.970162	10.029838	10.136108	10.165946	58
3	9.834189	9.863774	9.970416	10.029584	10.136226	10.165811	57
4	9.834325	9.863656	9.970669	10.029331	10.136344	10.165675	56
5	9.834460	9.863538	9.970922	10.029078	10.136462	10.165540	55
6	9.834595	9.863419	9.971175	10.028825	10.136581	10.165405	54
7	9.834730	9.863301	9.971429	10.028571	10.136699	10.165270	53
8	9.834865	9.863183	9.971682	10.028318	10.136817	10.165135	52
9	9.834999	9.863064	9.971935	10.028065	10.136936	10.165001	51
10	9.835134	9.862946	9.972188	10.027812	10.137054	10.164866	50
11	9.835269	9.862827	9.972441	10.027559	10.137173	10.164731	49
12	9.835403	9.862709	9.972695	10.027305	10.137291	10.164597	48
13	9.835538	9.862590	9.972948	10.027052	10.137410	10.164462	47
14	9.835672	9.862471	9.973201	10.026799	10.137529	10.164328	46
15	9.835807	9.862353	9.973454	10.026546	10.137647	10.164193	45
16	9.835941	9.862234	9.973707	10.026293	10.137766	10.164059	44
17	9.836075	9.862115	9.973960	10.026040	10.137885	10.163925	43
18	9.836209	9.861996	9.974213	10.025787	10.138004	10.163791	42
19	9.836343	9.861877	9.974466	10.025534	10.138123	10.163657	41
20	9.836477	9.861758	9.974719	10.025281	10.138242	10.163523	40
21	9.836611	9.861638	9.974973	10.025027	10.138362	10.163389	39
22	9.836745	9.861519	9.975226	10.024774	10.138481	10.163255	38
23	9.836879	9.861400	9.975479	10.024521	10.138600	10.163122	37
24	9.837012	9.861280	9.975732	10.024268	10.138720	10.162988	36
25	9.837146	9.861161	9.975985	10.024015	10.138839	10.162854	35
26	9.837279	9.861041	9.976238	10.023762	10.138959	10.162721	34
27	9.837413	9.860921	9.976491	10.023509	10.139079	10.162587	33
28	9.837546	9.860802	9.976744	10.023256	10.139198	10.162454	32
29	9.837679	9.860682	9.976997	10.023003	10.139318	10.162321	31
30	9.837812	9.860562	9.977250	10.022750	10.139438	10.162188	30
	Sine		Tangent		Secant		Minutes

46 Degrees.

43 Degrees.

Minutes	Sine	Tang.	Secant	
30	9.837812	9.860561	9.977250	10.022750
31	9.837945	9.860442	9.977503	10.022497
32	9.838078	9.860322	9.977756	10.022244
33	9.838211	9.860202	9.978009	10.021991
34	9.838344	9.860082	9.978262	10.021738
35	9.838477	9.859962	9.978515	10.021485
36	9.838610	9.859842	9.978768	10.021232
37	9.838742	9.859721	9.979021	10.020979
38	9.838875	9.859601	9.979274	10.020726
39	9.839007	9.859480	9.979527	10.020473
40	9.839140	9.859360	9.979780	10.020220
41	9.839272	9.859239	9.980033	10.019967
42	9.839404	9.859119	9.980286	10.019714
43	9.839536	9.858998	9.980538	10.019462
44	9.839668	9.858877	9.980791	10.019209
45	9.839800	9.858756	9.981044	10.018956
46	9.839932	9.858635	9.981297	10.018703
47	9.840064	9.858514	9.981550	10.018450
48	9.840196	9.858393	9.981803	10.018197
49	9.840328	9.858272	9.982056	10.017944
50	9.840459	9.858150	9.982309	10.017691
51	9.840591	9.858029	9.982562	10.017438
52	9.840722	9.857908	9.982814	10.017186
53	9.840854	9.857786	9.983067	10.016933
54	9.840985	9.857665	9.983320	10.016680
55	9.841116	9.857543	9.983573	10.016427
56	9.841247	9.857421	9.983826	10.016174
57	9.841378	9.857300	9.984079	10.015921
58	9.841509	9.857178	9.984331	10.015669
59	9.841640	9.857056	9.984584	10.015416
60	9.841771	9.856934	9.984837	10.015163
	Sine		Tangent	Secant
				Minutes

46 Degrees.

44 Degrees.

	Sine		Tang.		Secant	
0	9.84177	7.856934	9.984837	10.015163	10.142066	10.158229
1	9.841902	7.856812	9.985090	10.014910	10.143188	10.158098
2	9.842033	7.856690	9.985343	10.014657	10.143310	10.157967
3	9.842162	7.856567	9.985596	10.014404	10.143432	10.157835
4	9.842293	7.856440	9.985848	10.014152	10.143555	10.157703
5	9.842422	7.856323	9.986101	10.013899	10.143677	10.157570
6	9.842555	7.856201	9.986354	10.013646	10.143799	10.157444
7	9.842688	7.856078	9.986607	10.013393	10.143922	10.157315
8	9.842815	7.855951	9.986860	10.013140	10.144044	10.157185
9	9.842946	7.855833	9.987112	10.012888	10.144167	10.157054
10	9.843076	7.855711	9.987365	10.012635	10.144289	10.156924
11	9.843206	7.855588	9.987618	10.012382	10.144412	10.156794
12	9.843336	7.855465	9.987871	10.012129	10.144535	10.156664
13	9.843465	7.855344	9.988123	10.011877	10.144658	10.156535
14	9.843595	7.855219	9.988376	10.011624	10.144781	10.156405
15	9.843725	7.855090	9.988629	10.011371	10.144904	10.156275
16	9.843855	7.854973	9.988882	10.011118	10.145027	10.156145
17	9.843984	7.854850	9.989134	10.010866	10.145150	10.156016
18	9.844114	7.854727	9.989387	10.010613	10.145273	10.155886
19	9.844243	7.854603	9.989640	10.010360	10.145397	10.155757
20	9.844372	7.854480	9.989893	10.010107	10.145520	10.155628
21	9.844502	7.854355	9.990145	10.009855	10.145644	10.155498
22	9.844631	7.854233	9.990398	10.009602	10.145767	10.155369
23	9.844760	7.854109	9.990651	10.009349	10.145891	10.155240
24	9.844889	7.853986	9.990903	10.009097	10.146014	10.155111
25	9.845018	7.853862	9.991156	10.008844	10.146138	10.154982
26	9.845147	7.853738	9.991409	10.008591	10.146261	10.154853
27	9.845276	7.853614	9.991662	10.008338	10.146385	10.154724
28	9.845404	7.853490	9.991914	10.008086	10.146508	10.154595
29	9.845533	7.853366	9.992167	10.007833	10.146634	10.154467
30	9.845662	7.853242	9.992420	10.007580	10.146758	10.154338
	Si ne		Tang.		Secant	

45 Degrees.

44 Degrees.

Minutes	Sine	Tang.	Secant	Minutes			
30	9.845662	9.853242	9.992480	10.067580	10.146758	10.154338	30
31	9.845790	9.853118	9.992672	10.007328	10.146882	10.154210	29
32	9.845919	9.852994	9.992825	10.007075	10.147006	10.154081	28
33	9.846047	9.852869	9.993178	10.006822	10.147131	10.153953	27
34	9.846175	9.852745	9.993430	10.006570	10.147255	10.153825	26
35	9.846304	9.852620	9.993683	10.006317	10.147380	10.153696	25
36	9.846432	9.852496	9.993936	10.006064	10.147504	10.153568	24
37	9.846560	9.852371	9.994189	10.005811	10.147629	10.153440	23
38	9.846688	9.852247	9.994441	10.005559	10.147753	10.153312	22
39	9.846816	9.852122	9.994694	10.005306	10.147878	10.153184	21
40	9.846944	9.851997	9.994947	10.005053	10.148003	10.153056	20
41	9.847071	9.851872	9.995199	10.004801	10.148128	10.152929	19
42	9.847199	9.851747	9.995452	10.004548	10.148253	10.152801	18
43	9.847327	9.851622	9.995705	10.004295	10.148378	10.152673	17
44	9.847454	9.851497	9.995957	10.004043	10.148503	10.152546	16
45	9.847582	9.851372	9.996210	10.003790	10.148628	10.152418	15
46	9.847709	9.851246	9.996463	10.003537	10.148754	10.152291	14
47	9.847837	9.851121	9.996715	10.003285	10.148879	10.152163	13
48	9.847964	9.850996	9.996968	10.003032	10.149004	10.152036	12
49	9.848091	9.850870	9.997221	10.002779	10.149130	10.151909	11
50	9.848218	9.850745	9.997473	10.002527	10.149255	10.151782	10
51	9.848345	9.850619	9.997726	10.002274	10.149381	10.151655	9
52	9.848472	9.850493	9.997979	10.002021	10.149507	10.151528	8
53	9.848599	9.850367	9.998231	10.001769	10.149633	10.151401	7
54	9.848726	9.850242	9.998484	10.001516	10.149758	10.151274	6
55	9.848852	9.850116	9.998737	10.001263	10.149884	10.151148	5
56	9.848979	9.850000	9.998989	10.001011	10.150010	10.151021	4
57	9.849106	9.849884	9.999242	10.000758	10.150136	10.150894	3
58	9.849232	9.849737	9.999495	10.000505	10.150263	10.150768	2
59	9.849359	9.849611	9.999747	10.000253	10.150389	10.150641	1
60	9.849485	9.849485	10.000000	10.000000	10.150515	10.150515	0
	Sine	Tangent	Secant	Minutes			

45 Degrees.

North	South	Point	D	M	North	South
		$\frac{1}{4}$	2	49		
		$\frac{1}{2}$	5	37		
		$\frac{3}{4}$	8	26		
N by E	S by E	1	11	15	N by W	S by W
		$\frac{1}{4}$	14	4		
		$\frac{1}{2}$	16	52		
		$\frac{3}{4}$	19	41		
NNE	SSE	2	22	30	NNW	SSW
		$\frac{1}{4}$	25	19		
		$\frac{1}{2}$	28	7		
		$\frac{3}{4}$	30	56		
NE by N	SE by S	3	33	45	NW by N	SW by S
		$\frac{1}{4}$	36	34		
		$\frac{1}{2}$	39	22		
		$\frac{3}{4}$	42	11		
No. East	Sou. East	4	45	00	No. West	Sou. West
		$\frac{1}{4}$	47	49		
		$\frac{1}{2}$	50	37		
		$\frac{3}{4}$	53	26		
NE by E	SE by E	5	56	15	NW by W	SW by W
		$\frac{1}{4}$	59	4		
		$\frac{1}{2}$	61	52		
		$\frac{3}{4}$	64	41		
ENE	ESE	6	67	30	WNW	WSW
		$\frac{1}{4}$	70	19		
		$\frac{1}{2}$	73	7		
		$\frac{3}{4}$	75	56		
E by N	E by S	7	78	45	W by N	W by S
		$\frac{1}{4}$	81	34		
		$\frac{1}{2}$	84	22		
		$\frac{3}{4}$	87	11		
East	East	8	93	00	West	West

F I N I S.



W

W

7 S

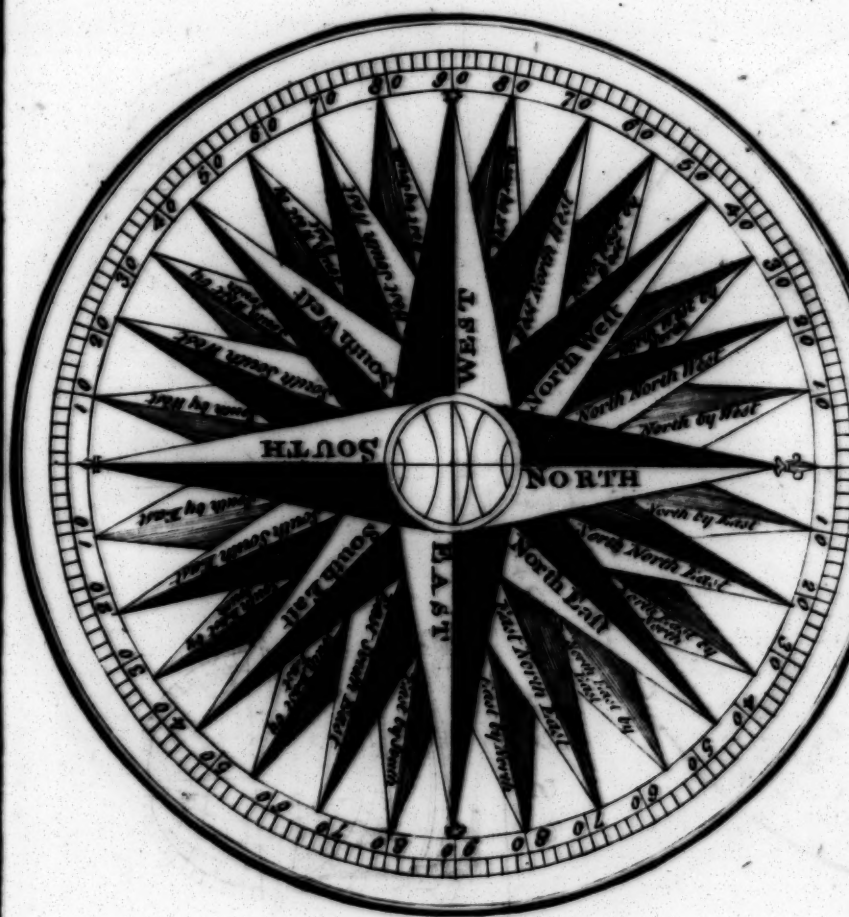
West

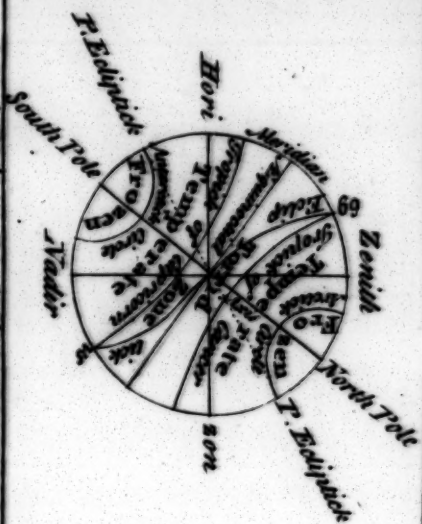
W

W

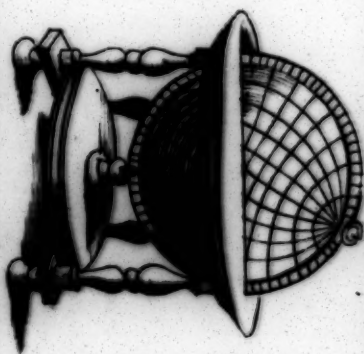
7 S

R

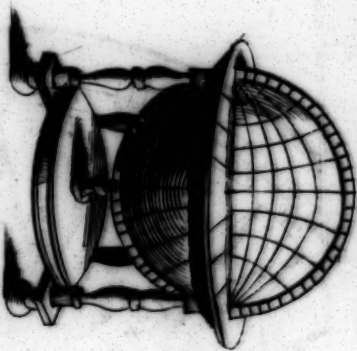




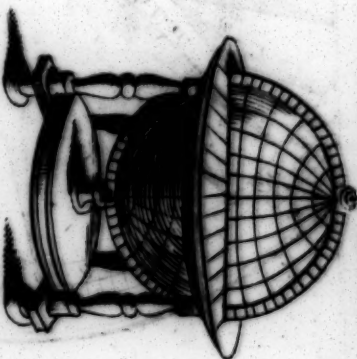
An Oblique Sphere .



A Direct Sphere



A Parallel Sphere.



THE MARINER'S COMPASS.

